Instruments

THE MAGAZINE of MEASUREMENT and CONTROL

Vol. 23 NOVEMBER 1950 No. 11

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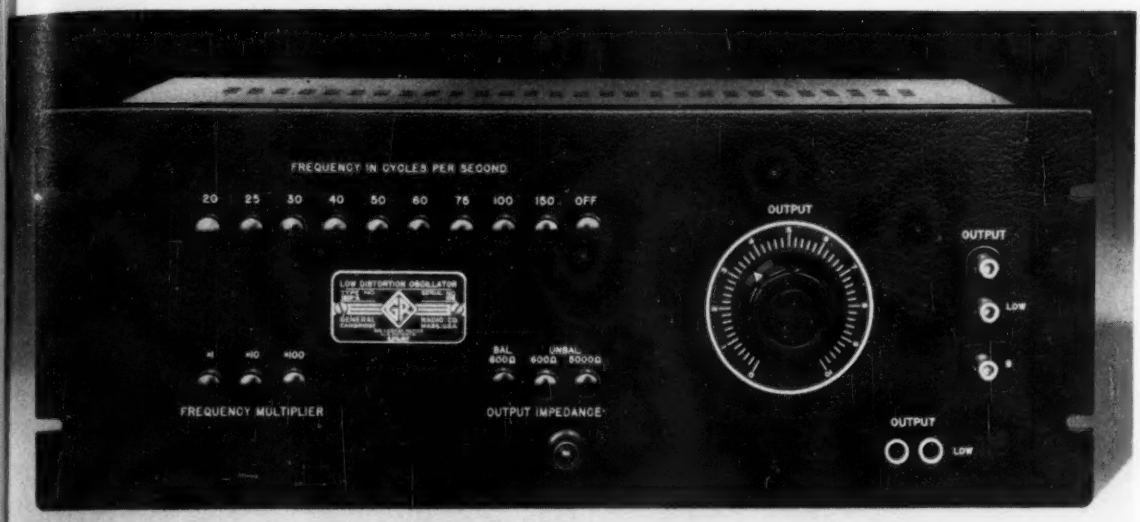

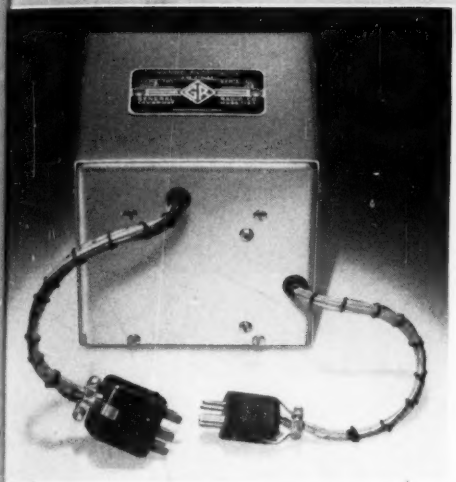

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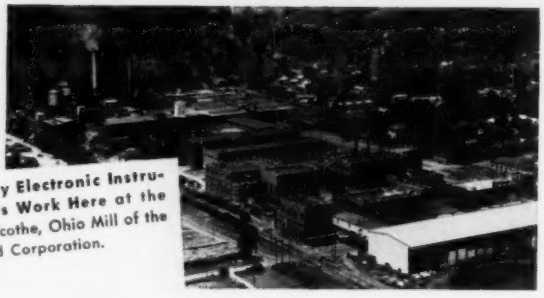

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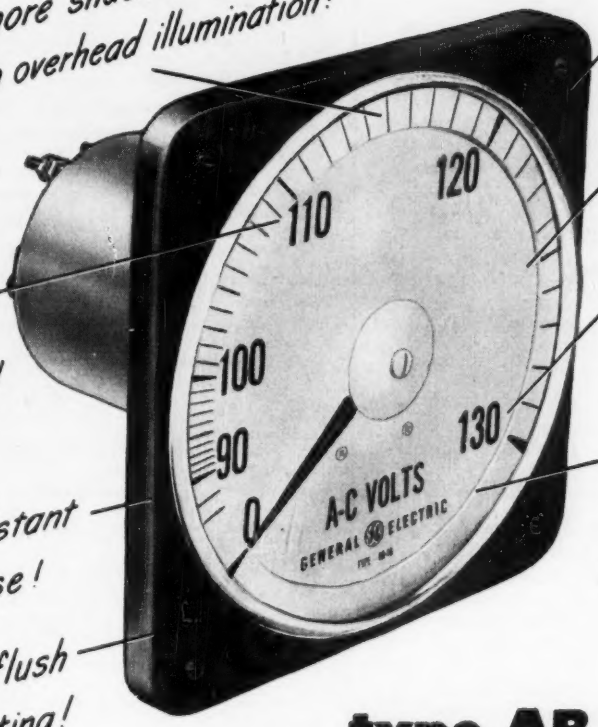

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Our Guests from Texas

IT is a pleasure to announce that *Instruments* has been selected as the medium of publication of the papers presented at the Fifth Annual Symposium on Instrumentation for the Process Industries, held October 11-13 under the auspices of the Chemical Engineering Department, Agricultural and Mechanical College of Texas. The opening paper, by John Lynch, the dynamic President of LaGloria Corporation, makes such a fitting Guest Editorial that we use it as such. It is followed in this issue by two other papers. The other seven (there were ten altogether) will be published as soon as possible. The entire proceedings, including the final Question-and-Answer Session, will be printed by The Instruments Publishing Company and will constitute a part of Texas A&M's own official program of publications. This arrangement will give well-deserved national publicity and utmost circulation to a "local" annual event which has become a national institution. —MFB

Economics *of* Instrumentation

By JOHN F. LYNCH, President, La Gloria Corp., Corpus Christi, Texas.

THE title, "Economics of Instrumentation," doesn't quite indicate what I have in mind to talk to you about today. I would like to go further afield into the general economic plan of our country which you technologists have helped to establish and into your duties as a very important part in our economic and social structure.

You know, we are increasingly dependent on one another! We are no longer self-sufficient to anything like the extent that the early settlers of our country were. In achieving our high standard of living we have become a nation of specialists and experts, completely dependent upon one another.

Over the last 25 years—and perhaps more than that—there has been a great tendency to have all production more highly technicalized. Production techniques, for the most part, have been narrowed down so most men have become experts in one particular field. The concentration is largely on mechanization.

I believe that some inefficiency resulting from this concentration is being acknowledged. I think it is correct to say that now in industry and in the better technical schools, the trend is towards wider diversification of general knowledge. And even experts must get along with their fellow men. A review of the reasons why many production men have to learn their positions shows that few have had to be changed or make changes because of lack of technical knowledge or background, but usually for some other reason—often too narrow perspective; not enough understanding about the general and basic parts of their particular jobs; or failure in human relations.

In this matter of human relations, most of you instrument men are leaders of people, either directly or indirectly. You have occasion to work with many people and you are looked upon as leaders because of your necessarily superior knowledge. In this leadership, I believe there are six fundamental requirements that were necessary in primitive society; are now; and probably will be in the foreseeable future. These requirements may seem a little academic to you. Most of them are so simple we may not think of them in our everyday turn of events so it is for that reason that I call them to your attention. They are:

1. Cultivate self-control and develop will-power and determination, so that you do the things you want to do or should do rather than be controlled by your immediate environment and sudden impulses. If you have not learned to control your own activities, to be your own boss rather than let circumstances dictate to you, you can hardly expect to be placed in charge of the activities of others and direct them in their work or be competent to guide any form of business, industrial, social or political activity.

2. Develop a tolerance of other people and their opinions and activities. As a part of this, learn to use the same measuring stick on your own activities that you apply in appraising others. In our modern society, where we are so dependent on one another, where so much is accomplished by group effort, this is particularly important.

3. Develop a proper respect for the truth and facts so that you will use the scientific approach to a problem rather than the dogmatic or superstitious one. This means that you take the rational rather than the emotional approach to all kinds of problems and have a full realization that the truth and facts will prevail.

4. Keep promises and commitments. Modern business and most of our social relations are based on confidence. People are judged, perhaps more than most of them realize, not only by what they do but by what they do in comparison with what they have promised or stated they could do. It is almost as bad to make promises that you have little or no chance of being able to keep as it is to make promises that you do not intend to keep.

5. Be willing to work and realize that work is a part of life and more than just a means to an end. You should be willing to make a social contribution in proportion to the social reward you expect. You should not expect your government or anyone else to look after you individually. You can only have freedom and independence when you are qualified to look after yourself. It is sometimes forgotten that, in this country, we the people are the government. The social contribution that each of us makes depends on his education, knowledge, experience, skill and willingness to work and cooperate with others.

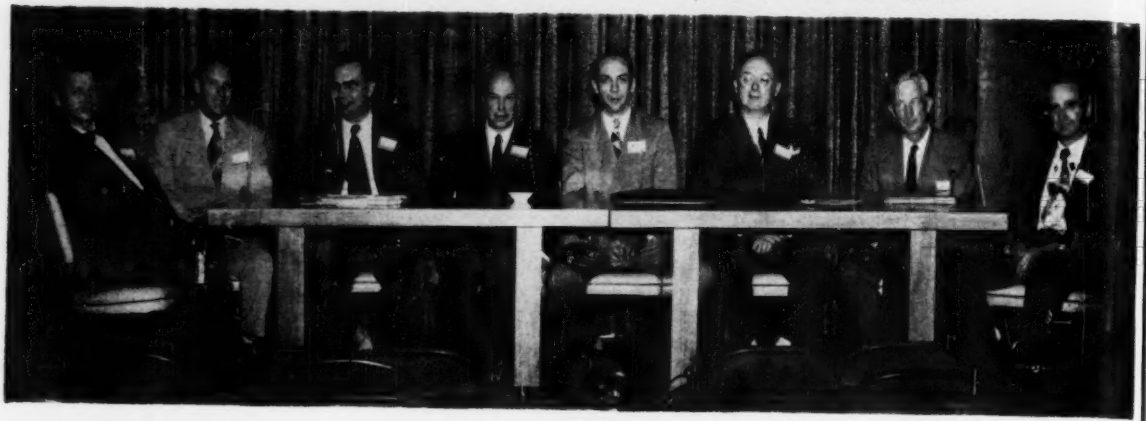
6. Realize the importance of maintaining your morale and of making the best of things, of pushing ahead with the adventure of life in spite of upset plans and temporary disappointments.

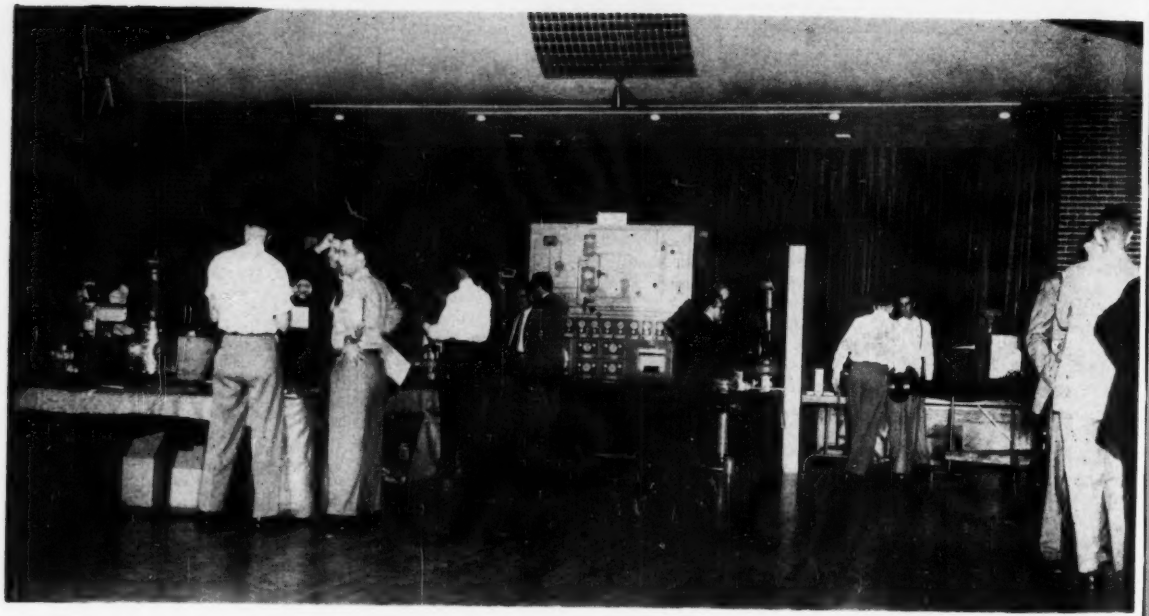
So much for your part in the social scheme. Now for your part in the economic plan.

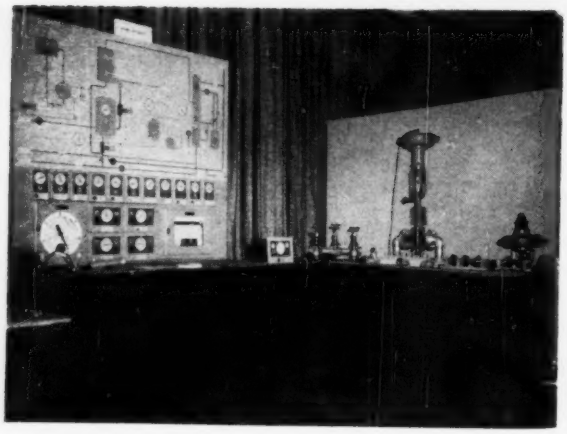
*Presented at the fifth Symposium on "Instrumentation for the Process Industries," Texas A.&M. College, College Station, Texas, Oct. 11-13, 1950.

Instruments' Pictorial on Texas A & M's Fifth Annual Symposium on "Instrumentation for the Process Industries"

Top picture, the speakers (left to right): Dr. B. W. Thomas, Mr. Homer C. Givens, Mr. R. E. Clarridge, Mr. W. T. Marchment, Mr. A. V. Novak, Mr. Porter Hart, Mr. R. A. Rockwell, Mr. R. C. King. Middle picture, the exhibit area. Bottom picture, two of the exhibits.







The progress of our country has resulted from two great basic inventions or discoveries made in the latter part of the Eighteenth Century. The inventions have had their greatest development and fruition in our country and together they have made possible our American comforts, culture and freedom from want. One of these, broadly speaking, was mechanical power; and the development of the physical sciences that went with it substituted slaves of iron and steel for human backs. The other invention was our political system with public education and individual freedom for all citizens, which promoted the initiative of millions and greatly accelerated scientific discovery, invention and the exploitation of natural resources. People fundamentally probably have not changed much, but their knowledge of the physical world is changing constantly.

Goods do not just happen. They come only from the united efforts of all of us working together. There is no way for the average American to have fifty percent more unless he produces more. No one can eat food that has not been produced. No one can ride in a motor car that has not been manufactured.

You instrument men are perhaps the most technical group concerned with the operation of plant or factory. You have had more to do directly through your techniques to reduce the amount of manpower required to do a unit of work. You also have a high vantage point and a good opportunity to know what goes on in the whole operation of your plant or factory.

I strongly advocate your taking full advantage of this rather unique position. In order to do the best job of instrumentation, you should understand thoroughly the entire process with which you are working. It is important that you be familiar with the rest of the plant or factory as the case may be. You should take advantage of this opportunity to learn even though certain phases of the operation are out of your particular scope. Ask yourself repeatedly, "Do I know and have a clear understanding of our whole objective? What can I do to make myself and my work valuable to this objective?"

You are in a position to know that it is, to a considerable extent, through a steady and fairly rapid increase in instrumentation that production has risen until the standard of living in these United States has reached its present peak.

To illustrate what the improvement of instrumentation has done I would like to cite my experience and that of my company. I had my first operating job in a plant a little less than twenty years ago. Of course, at that time, we had some instruments and motor valves, controls, etc., but plants of those days were certainly hand-operated affairs compared to those we have today. In our cycling and natural gasoline plant, which happens to be one of the largest gas processing plants of its kind, we have only ten men on shift. The plant has approximately three hundred instruments. This same plant twenty years ago probably would have had more than twenty men on shift and seventy-five instruments. The shift foremen in charge of operations take pride in their ability to adjust the automatic controls so that it is unnecessary to make a change for several hours. When the plant is running at a constant rate of feed input, it isn't uncommon to go four to eight hours without having to make a change. That is one of many examples that could be cited as to how instrumentation has improved production which, in turn, means more goods with less manpower, which ultimately means a higher standard of living for all.

In most countries of the world, people work hard with their hands for a mere pittance. In our country we work with tools—tools which multiply a thousand times the energy of man. Today there are more people just making tools and instruments for production than were engaged in all manufacturing a hundred years ago. In the past seventy years, of all the new industries which have sprung up, just fourteen of them* give employment, direct, or indirect, to an estimated thirteen million workers. In older industries, the number of workers has increased, too. In the period from 1870 to 1930, jobs multiplied by six and a half times in the glass industry; almost five times in the food industry; over two and three-quarters times in the textile industry; and, over five times in the lumber and furniture industries; while in the same period, population increased only three times. Today, most people know that the machine isn't an enemy, it's a friend—and that anything which helps us to turn out more work adds to our strength and prosperity. The intelligent use of production tools and instruments, is the difference between the abundance we enjoy and the scarcity that is the lot of the other people of the world.

It is our adequate supply of production tools and instruments, the knowledge to use them, and our system of free enterprise, that combine to make this country's amazing production record and the highest standard of living ever enjoyed by any people in all history. It has been estimated by good authority that our standard of living actually improves in the range of two to three percent each year. You men are responsible for substantially more than your pro-rata share of that increase.

It is because we Americans produce so much better for every hour we work that we earn more and can buy more. If each spent his whole week's wage for one basic food item, an average American worker could buy seventeen and a-half times as much bread as an average Russian worker; he could buy eighteen times as much milk as the Russian; and he could buy nearly eleven times as many pounds of beef as Mr. Stalin's countryman. And the end is not yet. We have learned that in the long run, when output per hour goes up, prices drop, so more people can buy and all of us gain; but when output per hour goes down, prices rise, so fewer people can buy and all of us lose.

Of course there are unusual periods when these principles don't seem to work—times when business is far above or far below normal. But over the long pull you'll find that these rules of productivity do apply. On the average, productivity has increased in the United States almost one-fifth every ten years since 1850.

As another striking example of the effect of this productivity on our standard of living: Do you know that there are more mechanical refrigerators in Amarillo, Texas, than in all of England plus all of France, with the cities of Berlin and Moscow thrown in besides? Let's look at those refrigerators. It all began when some Americans thought they could earn a profit making refrigerators. And they had the freedom of free enterprise to try—to take the risk. Then some other people, too, thought they could make a profit out of refrigerators, and they *also* had the freedom to try. Because of the competition, each had to try harder—to make better models and sell them cheaper. More and more of the profits had to be plowed back into the business to pay for more efficient tools and machines. As a result, a lot of people got jobs making tools and machines. And the manufacturers said to the people of Amarillo in their advertising that refrigerators help cut food costs, keep food fresher, and keep you healthier. So the people wanted the refrigerators, and demand caused the manufacturers to expand, creating more jobs. Prices of refrigerators kept going down, and wages and salaries kept going up, both because of increased productivity. The inevitable simply happened—the people of Amarillo wound up with more refrigerators than the people of England, France, Berlin and Moscow, combined.

The security, prosperity and well-being of Americans depend largely on the efficient production of American industry. There are two essentials of such efficient production.

The first is the effective application of technology to all our industrial processes. It includes better design of the product. It includes better tools and machinery with which to make the parts. It includes improved organization and administration in doing all the things that have to be done to deliver finished products to the customer, beginning with the raw materials.

The second essential of efficient production is the cooperation of employees. Such cooperation can be expected on the basis of a fair day's pay for a fair day's work. It also involves willingness on the part of employees to accept and use new tools and processes, and to qualify for new and different jobs. It requires a clear understanding of the right and responsibilities of both management and labor.

*Automobiles, electric machinery, rayon product, gasoline and oil, rubber tires and products, refrigeration, radio and phonographs, aircraft, tin cans and tinware, aluminum products, ice cream, cash registers and computing machines, lighting equipment, typewriters.

GRAPHIC PANELS

By A. V. NOVAK, E. I. du Pont de Nemours & Co., Sabine River Works, Orange, Texas

ABSTRACT. The development of automatic control panels is traced from local boards, through central control rooms, consoles, and finally to the new graphic panel. Advantages and disadvantages of the graphic are discussed. Approximate cost and space comparison is made with conventional panel boards.

RECENT years have seen a rapid increase in the use of automatic instrumentation in the field of continuous process control. Owing to the increasing demand of quality control, the increasing complexity of processes, and the growing need for manpower conservation, the automatic controller has been extended to monitor more and more points in the modern processing plant. With the increased demand for further monitoring and for the automatic control of processes both difficult and dangerous to handle manually, the controls have been taken from the field and put in a central location. The first step consisted of collecting controllers in a central spot. Formerly, controllers were located in the field with locally-mounted panels in the proximity of the process or variable to be controlled. As more and more of these points were developed, the desirablity of consolidating these to a central point became apparent. Hence, the so-called central control board was developed. Further developments of the central control board made it occupy an entire side of a room, an entire corner of the room, and finally an entire room. Coupled with safety measures, such as requirements for Class 1 Group D locations and new developments in the atomic field, the growing central board has found its place in a wholly separate building.

Each of these steps followed logically and each was an economic move over the preceding one. There comes a time, however, when one must step out of the traditional way of development and approach the problem differently to see if there is a better way of solution. In the case of the central control panel, the motivating influence of design was simplicity. This means both simplicity of operation and simplicity of maintenance. All points in the control system were brought to a central point to make it handy for an operator to carry on the work of the process. The central control board has now grown to somewhat large proportions and it is now frequently so large that the simplicity for which it was originally created has disappeared. True, it is performing a much larger job than was ever dreamed possible, but nevertheless, from the standpoint of the shift operator, who roams up and down a 100-foot panel, simplicity is hardly its correct title. It is hardly necessary to point out the desirablity of being able to train an operating man in a control room in a minimum of time or the necessity of avoiding confusion during routine operation. Therefore, any move which lends itself to reduction of confusion and increases the directness of approach has definite economic possibilities.

Toward this goal an increasing number of instrument men and instrument companies have been doing constructive thinking and designing along the lines of a console control board. This control board takes its name from the familiar console organ and in practice serves a similar purpose. In a console all the control variables are placed within easy reach of the operator seated at the center of the console. All control mechanisms are remotely located and only the records and means of moving the control points are brought to the console. The records are placed on multipoint instruments, thus allowing many records in a small space. This method consolidates the control data and adjustments to a single location and relieves the operator from running up and down a 100-foot control board to make settings. This is a great asset during times of upset and start-up. In some respects this arrangement may aid in consolidating a picture so necessary in today's continuous process. More and more engineers today are thinking in terms of an entire process and its interrelated functions rather than individual pressure, temperature and flow controllers. Toward this end the console has reduced the physical movements required in large and long panel boards but it carries the objection of increased confusion that exists with the consolidation of many uniform-looking controls and adjustments in a small place. With many records closely located, the possibility of mistakes has increased. Many remote-set points are located closer together, thus making mistakes possible—especially on that ever-blamed night shift.

To obtain the advantages of reduced panel space obtained by the console with remotely located controllers and to gain the simplicity of a direct, non-confusing arrangement, the flow sheet type of panel board is making its bid for consideration. The flow sheet board or, as it is more commonly known, the graphic panel, is not a new invention in itself. Several approaches to the graphic panel are in operation today, especially in the modern power generation and distribution plant. The power industry has used the graphic panel in modification for some while. In that industry, just as in the chemical industry, the complexity of many related switches became so great that some means of simplification was necessary to avoid error. The power industry uses the graphic panel by laying out an entire picture of a distribution net work with relay switch handles in exactly the same spot that a power disconnect may appear in the field. This, in connection with indicating lights, aids the power dispatcher in making proper connection for remote-switching operations.

Coming a little closer to the chemical industry, one has only to look at the Houdry process panel to find another approach to the graphic presentation of control information. The Houdry board is best described in terms of a supervisory board in that it indicates to the operator what has happened in the process and aids him in keeping current with the automatic process occurring in the plant. Usually such a board is on one side of the control room, while the other side is lined with conventional controllers. Such a system actually increases the size and cost of the control room, but it does serve a useful purpose in providing a graphic indication of existing conditions. Again note should be taken of the desirability of simplicity and aid in furnishing information to the operating man to insure that a correct job is done most efficiently.

In the most recent version of the graphic panel, the process under control is drawn out in diagrammatic or graphic form on the side of the control room. The use of color is important in keeping streams identified. Emphasis should be placed on the fact that the pictures and the colors are not used for decorative purposes as is so often charged by those who object to this type of instrumentation. It should be stated here that nothing should go on the graphic panel except those things which lead toward simplicity and directness of approach. Standard and simple symbols should be used throughout.

For each location in the actual plant where some type of control is used, a small unit is installed in the corresponding point in the flow sheet; and it serves a multiple purpose. This unit has on it a dial with several knobs. Although several variations are on the market today, the usual design calls for a space about four inches square on the panel. All units have a dial which gives a continuous indication of the process variable under control, be it temperature, pressure, flow, etc. By means of knobs and switches one can indicate the control-valve air pressure loading and the set point. There is also a means of switching from automatic to manual control. In most cases the actual control mechanism is located on the job near the point of measurement where the conventional transmitter

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is usually located. The operator has then before him a continuous indication of the process, a continuous indication of the set point, indication of the control valve loading pressure, and a means of conveniently transferring from automatic to manual and back to automatic without upset to the process.

What in fact has happened is that when a process became so large so as to make it impractical for an operator to physically open and close the various valves in the field, a device was made so as to bring the essential information of the field to the operator and present it to him on a control board which has the exact appearance of the process in the field. As an operator would normally reach for a valve handle to make a temperature adjustment in the field, he now reaches for that same valve in the same line as depicted on the graphic board and makes the same adjustment. This is an important point, because one of the basic reasons for a graphic panel is simplicity of design, directness of approach and the elimination of confusion in the operation of today's complex plants.

To proceed further on the development of the mechanism of a graphic panel, let us consider the location of the controller. As previously pointed out, the controller is usually located in the field at the point of conventional transmitter location. Extended work has been done on the merits of close-coupled control systems which result in a minimum of transfer lag. The merits of such a system have definitely been proved for processes of short characteristic times. In this category fall flow, pressure, ratio and possibly some temperature control systems. Field tests have actually proved that a much narrower throttling band and faster reset rates are possible with close-coupled control systems by virtue of reduction in the characteristic time of the control system. Much could be developed about this particular point but it was brought into this discussion for the prime purpose of indicating that such advantages are natural with graphic panel installations. If one disagrees with such design, there is nothing to prevent the location of the control units immediately behind the graphic panel. In fact, this is usually done in the case of temperature controls where the transfer lag is a small part of the total characteristic time of the system.

Another objection quite frequently pointed out in connection with field-mounted controllers is that of inconvenience to the maintenance man when doing repair work on the controllers. The desirability of performing repair work in air-conditioned control rooms versus that of field-mounted controller certainly has merit. However, most modern installations use transmitters which have to be located in the field. As such, the addition of a controller to the transmitter usually does not add too much in the way of field maintenance. The advantage of housing controllers centrally versus the advantages of close control loops must be weighed and the decision for final location made accordingly.

In connection with maintenance of graphic panel type instruments, a somewhat different approach should be made for most efficient operation. With conventional instrumentation, maintenance was of necessity performed in the control room on the particular controller in question. With the unitized type of instrumentation made possible by the graphic panel, this is changed to some degree, since all controllers and board-mounted indicators are identical regardless of their service. A greater degree of interchangeability is possible. By maintaining not more than six different units, essentially the entire system can be interchanged and repairs can then be made in the shop where proper facilities are available for a standardized type of maintenance. This, of course, has reference to the type of maintenance one would normally do under preventive maintenance or breakdown maintenance. During the time of turn-around or complete plant shutdown for overhaul, this system has its limitations owing to the objectionably high number of spare units which would be necessary.

The present system calls for an indication of the controlled variable in the field by means of a pressure gage, as well as an indicating dial on the graphic panel. If a record of these variables is desirable, a multipoint recorder is located on a separate board in the control room. Various ramifications of this recorder location have been tried. In some cases they have been located at the bottom of the panel; in other cases, intermingled with the graphic features of the board. Again, each application has to be reviewed with individual merits applying. It should be pointed out that in actual operation of such a board the records are ordinarily not used for routing operation. They are used for indication of trends during start-up and for indication of trends during an upset. Records are useful for review by supervisory personnel for performance during the two night shifts. It should be pointed out that there is available on the market today a small strip-chart recorder that will fit into the spot on the graphic panel in place of the conventional miniature panel which has only an indicating dial. There are various arguments pro and con for the advisability of such a miniature recorder. In addition, various signal lights or even motor start-stop stations may be placed on the board for various pumps and motors. In so doing, however, the three main goals of the graphic panel should be kept in mind—simplicity, compactness, and directness of operation.

The advantages of a graphic panel are as follows:

1. A unitized picture of the process to the operating man.
2. Consolidation of control variables in a central area, but not as consolidated as the console.
3. The reduction of panel board space.
4. A reduction of size and cost of the control room.

The disadvantages of this system are:

1. Increased decentralized location of control mechanisms.
2. Increased effort necessary in having throttling band and reset adjustment decentralized. This is especially irksome during start-up.
3. Increased number of transmitter lines.

The first disadvantage is compensated for by the increased control performance of close control loops. It also places the controller in the primary transmission line, thereby eliminating the number of mechanisms through which a signal must go before it reaches the controller proper.

The second disadvantage is admittedly a somewhat troublesome one. After start-ups however, adjustments of these variables should occur very seldom. In fact, some engineers point out that the location of these adjustments at a remote point will reduce unauthorized tinkering. This point is definitely a two-sided question and there are as many engineers branding this an advantage as there are those who consider it a limiting factor.

One of the most frequently presented charges against the graphic panel is that of inflexibility. It is charged that when revisions of the graphic panel are to be made, difficulty will exist in changing the face of the panel. This charge does not seem justified when one analyzes what happens in the conventional panel when alterations are necessary. In the conventional panel one has the entire side of the control room lined with controllers, each occupying roughly an area of about 18 x 18 inches. When an alteration is necessary, the removal of large instrument cases is involved. Usually cases of different size and shape are needed and cutting and/or welding of the panel board is necessary to accommodate the new case shape. This is what is necessary when an existing installation is changed to another function, such as converting a base pressure controller on a column to a temperature controller. In almost all cases where a different case shape results, a tedious alteration to the panel is involved. So much for the alteration of a conventional board where changes are involved. If an addition is involved, such as the addition of another column or instrumentation on a preheater that was not formerly allowed for, the problem of finding a two-foot-square area on the panel for a controller presents a problem. One has two choices—that of installing extra pens and controls on existing instruments or moving down to the end of the board and installing the instrumentation for the new addition in a very illogical location in relationship to the rest of the process. This remote location has actually been done in several cases. It can be seen that the alteration of the conventional board presents quite a problem.

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CONTINUOUS ANALYZERS

By B. W. THOMAS, Humble Oil & Refining Co., Baytown, Texas.

Introduction

DURING the past twenty years, many laborious chemical analysis procedures have been replaced by the development of rapid spectroscopic and electronic techniques. It was during this period that such relatively complex analyzers as mass spectrometers, infrared and ultraviolet spectrophotometers, emission spectrographs, x-ray photometers and electron miscroscopes were designed, built and placed in operation as reliable analytical tools. These instruments are employed in both research and routine laboratories in which detailed information is made available relatively quickly on diverse and complicated samples. It has been more recently—during the past two to four years—that efforts have been directed intensively toward further simplification of analytical work by elimination of the necessity of submitting process samples to laboratories. Instead, the present trend is directed at placing analytical tools in plant control rooms so that process operating variables can be followed more closely and corrected more quickly than is possible on a sample-to-laboratory basis.

In the development of instruments for plant service particular attention has been given to rugged construction and dependability of operation under severe atmospheric temperature and humidity conditions, as well as safety features. Instrument developments, some of which have been tested satisfactorily and others for which tests are under way at present, include the nondispersion infrared analyzer, the dielectric constant meter, the densitometer (or gravitometer), the refractometer, and the viscometer. It is the purpose of this presentation to discuss the operating principles of a few of these instruments and describe several applications that have been made to date.

Discussion

Infrared Analyzers

There are several different models of nondispersion continuous infrared analyzers but in general the operating principles of these instruments are somewhat similar. In the absence of prisms for dispersing the light, use is made of the entire infrared energy region between 2 and 14 microns and measurements for individual compounds in fairly simple mixtures are based on spectral differences between the component desired and the other materials in the mixture. It is common practice in nondispersion infrared instruments to employ a sample cell, a filter cell, a compensator cell, and an interference cell in sensitizing the instrument to one component and desensitizing its response to all other components in the mixture. The filter and compensator cell are arranged for absorption of light in opposite paths of the double-beam instruments whereas materials in the sample and interference cells absorb light from both beams. The material employed as windows for these optical cells of the analyzer may be sodium chloride, calcium chloride, silver chloride or, in special cases, quartz. Sodium chloride windows offer the least resistance to passage of infrared energy but the high susceptibility of sodium chloride to moisture limits the use of this material for cell windows.

In sensitizing an infrared analyzer to a particular analysis, it is customary to place the sample component for which a measurement is desired in the filter cell and the sample components other than that for which a measurement is to be made are placed in the compensator cell. Mixtures of nitrogen and background gases are placed in the interference cell. Although some theoretical computations have been made for sensitization of the infrared analyzers, for the most part this work is largely performed on a trial-and-error basis.

There are two general types of infrared nondispersion analyzer receivers. One employs either a bolometer or thermopile in which the measurement depends upon a change in temperature produced by energy transmitted by the sample and sensitizing gases. In the other instrument, the two beams of energy, after passing through the sample and sensitizing gases, are caused to fall on opposite sides of a cell which is divided into two compartments by an extremely thin diaphragm. A low-cycle interrupter causes the two beams of energy to reach the receiving cells in opposite phase such that the diaphragm is caused to vibrate to the amount of energy difference between two beams.

Some of the more common applications of the infrared analyzer are the measurement of carbon dioxide in air, and carbon monoxide in flue gases. The infrared instruments have been employed satisfactorily in the determination of ethylene in ethane and methane, for the measurement of isobutane in normal butane and isopentane. Another application that appears attractive for the infrared analyzer is the measurement of either ethane or isobutane in LPG propane. Also included in the applications that have met with success to date is the determination of isobutane in normal butylene and butadiene in styrene.

Manufacturers from which infrared analyzers may be purchased include Baird Associates, Leeds & Northrup, Mines Safety Appliances, Applied Physics Corporation, and Philips Incorporated.

Densitometers

Densitometers of several different design features have been placed on the market during the past two years and density measurements with accuracies of two units in the fifth decimal place have been claimed. Three of the densitometers on the market employ the hydrometer principle, another employs a float bulb on a lever arm and scale mechanism, still another employs a differential pressure measurement. Perhaps the most sensitive densitometer employs the velocity of sound through a vapor phase sample as a measurement of density.

In the case of hydrometer type instruments, the use of an electromagnetic pickup is employed in each case for locating the exact position of the hydrometer bulb. In one instrument the hydrometer bulb is connected to the exterior walls of the sample system by means of a chain. As the density of the material passing through the sample system increases, additional lengths of the chain are supported by the additional buoyancy on the float bulb. For this instrument, sample flow rates may be varied from 0.1 to 0.5 gallons per minute without affecting recorder reading of the float position. Arrangements can be made whereby liquid sample streams under pressures up to 500 psi. may be passed through this instrument which employs a stainless steel tube for housing of the float. The densitometer employing a constant-volume sample bulb attached to a lever arm and scale mechanism has been used satisfactorily for controlling operations in which two liquids are blended to a desired composition.

The differential-pressure type densitometer embodies two tubes of different lengths which extend down into the material whose density is to be measured. As air or water is bubbled through these pipes which extend to different levels, their differential pressure requirements are a direct function of the density of the material under test. This densitometer has found use in mixtures containing solid particles in suspension or in mixtures for which flow characteristics would be difficult to control.

Some of the successful applications in which continuous density recording mechanisms have been used include the measurement and control of butadiene-styrene ratios in synthetic rubber plants. Reaction rates or percent conversion of hydrocarbon to latex rubber have been measured

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by the differential-pressure type densitometer, and liquid-level interface controls have made use of the floating-bulb type densitometer. Continuous recording densitometers have been employed in the measurement and control of hydrocarbon-water ratios in which 30 to 40 percent hydrocarbons form a homogeneous emulsion with the water. They may be used in indicating and possibly for controlling the extract-raffinate interface in phenol extraction towers by sampling the tower alternately above and below the interface level.

Some of the sources from which continuous recording densitometers may be purchased include Precision Thermometer & Instrument Co., American Recording Chart Co., Leeds & Northrup, Fischer Governor, and The Poole Instrument Co.

Dielectric Constant Meters

The dielectric property of organic materials is an important and easily measured physical characteristic that has had only limited attention. Its utility in measuring certain single components or multicomponent types in admixture with other known types of compounds may even surpass the value of knowledge gained from such well-established measurements as boiling points, density, or refractive index. For certain paraffinic type hydrocarbons there appears to be a rule-of-thumb correlation between dielectric property and the square of the refractive index. Olefinic type hydrocarbons exhibit higher dielectric properties than do paraffins, and aromatic type compounds possess still greater dielectric constant values. In general, the dielectric property of oxygenated compounds are considerably higher than this property for hydrocarbons. This is especially true for a material such as water which exhibits a dielectric constant value of 80 in comparison to a dielectric constant value of around 2.2, in general, for petroleum products. It should be mentioned, however, that the dielectric constant properties of two materials in admixture do not necessarily add linearly. This non-linearity condition is known to exist for mixtures of alcohol in gasolines, and the same would be expected to be true for water in hydrocarbons.

The dielectric constant property of all materials is measured relative to the dielectric constant value of unity for air. Dielectric constant is itself defined as the ratio of capacitance for a fixed capacitor, filled first with the material under question and then with air. Since the capacitance of a capacitor can be measured electrically by application of high-frequency alternating circuits, it lends itself quite well to continuous recording of dielectric constant. Electrical capacitors of the rod-and-cylinder type can be arranged for the continuous flow of liquid samples under pressures of several atmospheres. If a straight dielectric constant measurement is desired, it may be obtained simply by balancing the oscillating circuit before and after addition of the material under question.

In a continuous-measuring dielectric-constant meter, the sample under test is passed continuously through a capacitor element which forms a part of an oscillating circuit. As the dielectric constant or percent composition of one component of this material changes, the oscillating frequency changes correspondingly. Rather than attempt to measure the small frequency change in a high-frequency oscillator, it is customary to pass the output frequency of this variable-frequency oscillator together with the output frequency of a constant-frequency oscillator into a mixing-frequency oscillator in such a manner that the difference in frequency is made available to a frequency meter and a recorder. In this type of instrument, small changes in sample composition (dielectric constant) can be measured and recorded in a highly satisfactory manner.

In another type of dielectric-constant meter, two capacitors are contained in a single oscillating circuit. One is employed for the material under test, whereas the other forms a part of a recording bridge system. As the dielectric constant of the material under test changes, the vibration frequency of the circuit changes correspondingly. In order to nullify this affect, the capacitor in the recording element is turned in the opposite direction automatically and a trace of this motion appears on the recorder chart. By calibrating these systems with samples of known compositions, it is possible to employ them to read directly in terms of the component for which an analysis is desired.

Some of the applications to which dielectric-constant meters have been applied include water, alcohol, or phenol in hydrocarbons. The dielectric property has been employed in a continuous manner for thickness measurement of paper and fibers of various types. Based on limited literature data, the dielectric property may be employed for measurement of paraffins in naphthenes, or aromatics in other types of hydrocarbons. In these applications, particular care must be exercised in maintaining relatively constant distribution of background components.

Sources from which dielectric-constant meters may be obtained include the Foxboro Co. and the Oil Well-Water Locating Co. for continuous analysis instruments, and the Yellow Spring Instrument Co. for a spot sample type dielectric-constant meter.

Refractometers

Refractive index is a well-established physical property, values for which may be found in the literature for most pure compounds. This property is the ratio of light velocities in air and in the material under question. Since the differences in the velocity of light in the two materials is proportional to the refraction or bending of light at the two surfaces interfaces, the latter is commonly used as a measure of the refractive index. Refractive index also is related to the intensity with which light is reflected from the interface of two materials. Thus, either transmission or reflection type instruments may be employed in the measurement of refractive index. Transmission type refractometers are employed satisfactorily in the measurement of transparent liquids or solids, but reflection type refractometers are required for the measurement of refractive index for semi-transparent materials. During World War II, effort was directed toward the development of a continuous refractometer of the transmission type, and since the war a reflection type refractometer has been developed.

In the continuous-transmission type refractometer, the sample flows through a wedge-shaped compartment, one side of which is a glass prism. Light from a suitable source, usually a sodium arc, enters through the sample compartment window and passes along the sample-prism interface. Some of the light is refracted along the interface, passes through the glass prism to form the familiar light-dark interface on a visible scale as well as on a narrow slit mounted in front of a movable multiplier phototube. Arrangements are provided whereby the phototube assembly is caused to move up or down in accordance with the light-dark interface and an associated pen and lever mechanism affords a permanent record of variations in refractive index.

In the reflection type instrument, the intensity of reflected white light as received by a photoelectric cell serves as a measure of the refractive index. Since the light is not required to pass through the medium under test, a prism mounted in the side of a flow line affords a simple method of measurement of refractive index for either transparent or opaque materials. Also, since changes in refractivity are readily converted in the reflection type refractometer into a change in electrical current or potential, standard recorders and/or controllers are easily adapted to the measurement. The phenomenon of internal reflection upon which this refractometer is based may be employed also for control of liquid level.

Applications for which refractive index instruments have been employed include vinyl and vinylidene chlorides, styrene in ethylbenzene and butadiene, naphthenes in paraffins, aromatics in both paraffins and naphthenes, individual components in binary mixtures of hydrocarbons. Reflection type refractometers have been used to determine per cent conversion in GRS laytex polymerization plants. Benzene concentrations in butyl alcohol solutions have been measured.

Manufacturers who have done considerable developmental work on refractometers include the Shell Development Co.,

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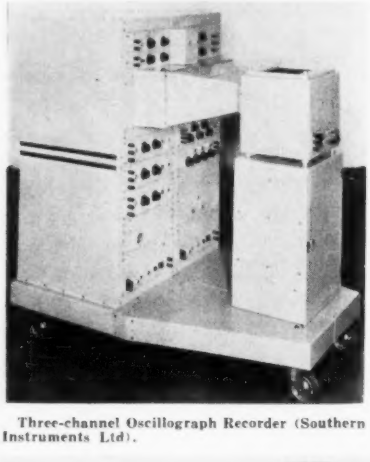
The 1950 British Electronics Symposium *and* Exhibition

By the European Correspondent of *Instruments*

IN THE calendar of instrument users in the United Kingdom the Annual Electronics Symposium, organized by the Scientific Instrument Manufacturers of Great Britain, has assumed considerable importance. For the past two years the papers read at the Symposium have been accompanied by an Exhibition, and this popular feature was retained for the 1950 Symposium. Some twenty-five firms exhibited and a number of new instruments were on view.

Much interest is being shown in Great Britain on electronic equipment for indicating and recording static and dynamic strains in many types of structures. An equipment for this purpose, shown by Elliott Brothers Ltd. (London), provides on a single cathode-ray tube a simultaneous display of dynamic strain at ten points. Strain gages of the resistance type may be employed and alternative forms of display, i.e., amplitude or wave-form, may be selected by means of a switch. An entirely novel feature is the use of pulse excitation of the strain-gage bridges, thus eliminating the difficulties usually associated with d-c. amplification and the effects of stray capacitances experienced when a-c. is used. Ten synchronized pulse generators are used for excitation, interconnected so that the pulses follow one another in turn with an interval after the tenth pulse. One bridge is energized at a time and the bridges are in parallel, connected to a common amplifier.

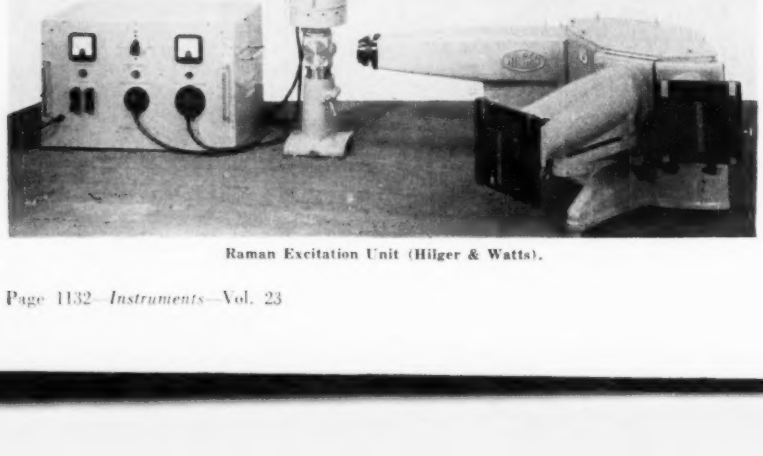
A new three-channel trolley-mounted oscillograph recorder manufactured by Southern Instruments Ltd. (Camberley) consists of an oscillograph unit and a pre-amplifier unit and will record three variables and time. The records are taken on 70-mm. film or paper and the trace from each tube covers almost the full width, the time or event marks being at one side. The advantage, therefore, is that large overlapping trace records of three variables are obtained. It meets the demand of users who must have records that are easily examined and measured. It has a useful recording speed range, events lasting up to 0.1 millisecond being clearly recorded. The optical system employs three lenses and a mirror system to converge the light paths onto the film. Either continuous-feed or drum methods can be used to record the three tubes, but the center tube can be used for still records, using either the repetitive or single-sweep time-base.



Three-channel Oscillograph Recorder (Southern Instruments Ltd).

Electronic Instruments Ltd. (Richmond) showed their new model vibrating reed electrometer, notable for its high input resistance and its exceptional stability. It is primarily designed for the measurement of small ionization currents, but can be used as a general-purpose high-impedance millivoltmeter and, in a modified form, as an ultrastable pH meter. The input impedance is greater than 10^{16} ohms and the long-term drift does not exceed ± 100 microvolts.

Among the instruments shown by Cinema-Television Ltd. was the microsecond counter chronometer. The timing ranges provided are from one microsecond to one second with an accuracy of ± 0.005 percent ± 1 microsecond and 10 microseconds to 10 seconds with an accuracy of ± 0.005 percent ± 10 microseconds. It consists essentially of two crystal-controlled oscillators, an "electronic gate," six decade units in cascade and a stabilized power supply. A switch enables either a 1-Mc. or a 100-kc. internal oscillator to be chosen, giving timing ranges of 1 second and 10 seconds respectively. On receipt of a "start" pulse that "gate" is opened and the decades count the individual cycles emanating from the oscillator. This continues until a "stop" pulse is received when the "gate" shuts, leaving displayed the number of cycles executed by the oscillator: microseconds or tens of microseconds according to the oscillator frequency selected.



Raman Excitation Unit (Hilger & Watts).

Shown by Airmec Laboratories Ltd. was their new millivoltmeter type 784. This instrument consists essentially of a wide-band amplifier, stabilized by negative feedback over the frequency range 30 cps. to 5 Mc., followed by a diode voltmeter. A low-capacitance cathode-follower probe unit feeds into the 3-valve feedback amplifier, has approximately 18 db of negative feedback over the frequency range, and is followed by a cathode-follower feeding a diode rectifier. The input multiplier provides ranges of 0 to 10, 0 to 100, and 0 to 1,000 millivolts. A point on the cathode-resistor of the cathode-follower output valve is connected to a coaxial output socket, enabling the millivoltmeter to be used as a wide-band amplifier, having a gain of approximately 30 db, a high input impedance, and a low output impedance.

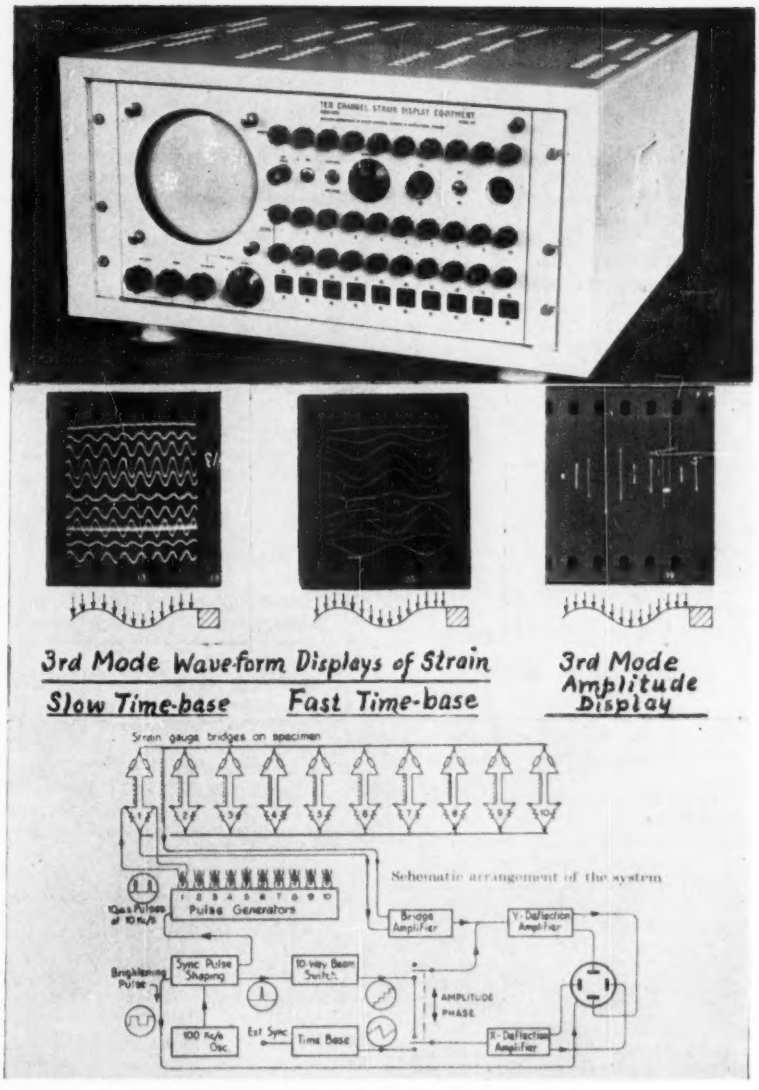
The Baldwin Instrument Company Ltd. (Dartford) was the first in the United Kingdom to produce, commercially, radiation measuring instruments. Recently availability of radioactive sources in this country has enabled this firm to combine its experience of radiation measurement with their knowledge of industrial control. The Baldwin "Atomat" gage measures the weight per unit area of the material passed through it. The material does not contact the gage, can pass through it at any speed, and is not affected in any way. The radioactive source and the ionization chamber are mounted on opposite sides of the material to be gaged. The working distance between faces is usually about one inch but can be more if necessary. The shape and area scanned by the gage can be made to suit special requirements but a scanned area of 4 by 23 centimeters is standard. There are two remote indicating instruments: one reads weight per unit area, or thickness of material of constant density. The other shows deviation above or below a preset level.

A new high-power stroboscope developed by Dawe Instruments Ltd. is known as the "Stroboloom" and the intensity of the flash is such that it is adequate for direct inspection of the moving parts, under well-lighted factory conditions. The duration of the flash is about fifty microseconds and the maximum flash rate 220 per minute.

Baird and Tatlock Ltd. (London) showed their new self-balancing photoelectric absorptiometer for chemical analysis. The requirement was for a

instrument which would measure small changes in the color of a liquor being used in a chemical process, and provide continuous quantitative records of these changes. With suitable color filters the instrument may be calibrated to record the composition of any liquid whose absorption can be related to some form of chemical analysis or turbidity. It is based on the principle of automatic rebalancing, using negative feedback; vacuum emission-type phototubes are employed in adjacent arms of a bridge measuring circuit. Light from the lamp passes through two identical absorption cells containing the liquor being analyzed and a standard. Absorption of all or part of the light falling on one of the phototubes causes an out-of-balance emf. to appear across the bridge. This emf. is amplified and applied to a mirror galvanometer placed in the light path so that the beam moves to increase the area of illumination on the phototube affected. Thus the bridge is automatically rebalanced and the galvanometer current will be a function of the initial disturbance. The time lag was required to be small, and since only a small quantity of the liquor (about 2 cc./min.) was available for this time, the absorption cells themselves were small, and such that only 5 percent total light absorption could be obtained to give full-scale deflection for color changes of the magnitude to be detected. The arrangement is reasonably independent of variations in lamp intensity, amplifier gain and phototube characteristics. (In particular, it can be shown that insensitivity to fluctuations in the gain of the amplifier is in fact achieved by making the gain high.)

Much interest has been stimulated in the past decade on both sides of the Atlantic in spectrophotometry and close attention to this has been paid by Hilger & Watts Ltd. New forms of recording spectrophotometers for ultraviolet, visible region, and infrared measurements almost invariably use cyclical interruption or "chopping" of the radiation falling on the radiation receiver so that a-c. methods of signal amplification can be used. This is particularly important in infrared spectrophotometry in which the radiation signals are often near the limit of detection and where, too, the effects of ambient temperature changes have to be avoided and amplifier drifts minimized. The purpose of this response tester is to indicate the relative response of an infrared receiver to radiation interrupted at different frequencies with a view to standardizing the performance of receivers such as the Hilger Schwarz thermopile, and the selection of the optimum working frequency for a chopped radiation system. The equipment is primarily for measurements on infrared receivers but it will be possible to adapt it for tests on other elements, such as photocells and phototubes. The system demonstrated employs a sector disk to give approximately square-wave "chopping" of the light falling on the thermopile,



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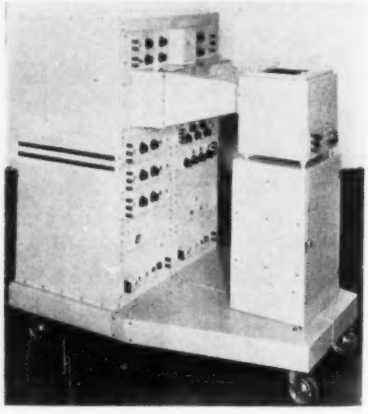

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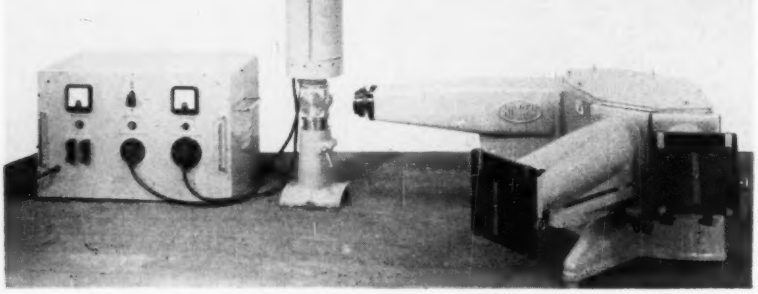

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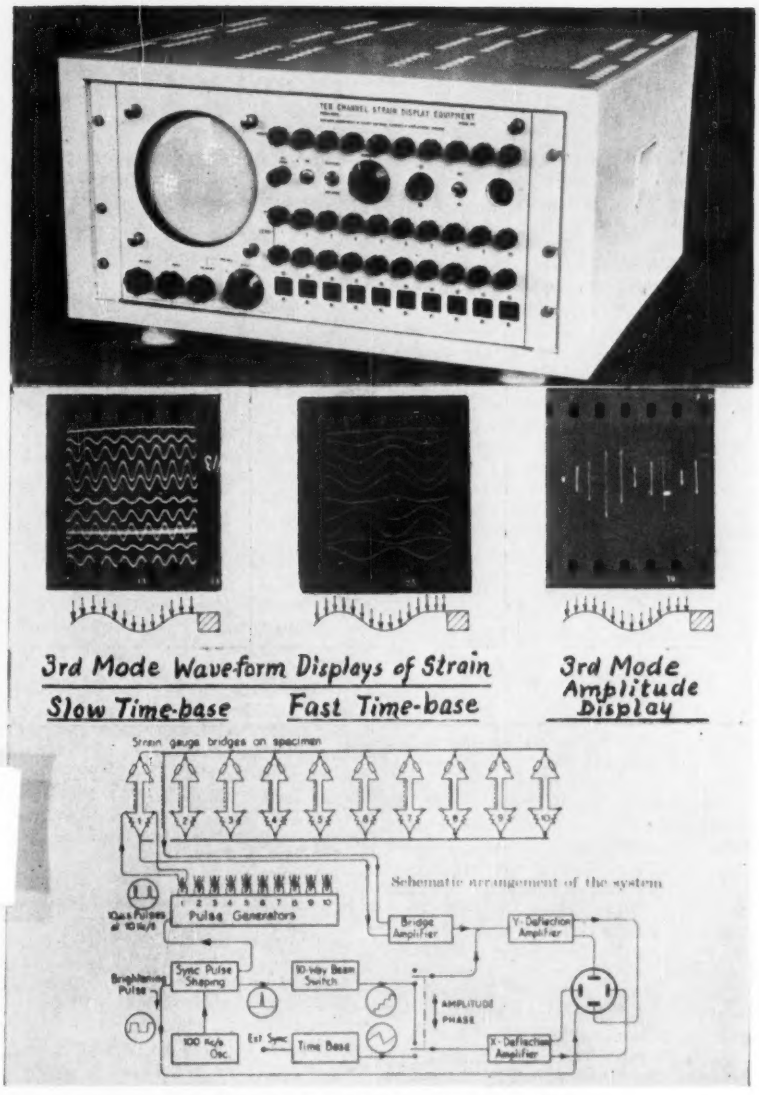

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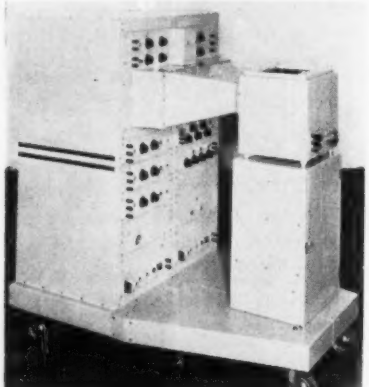

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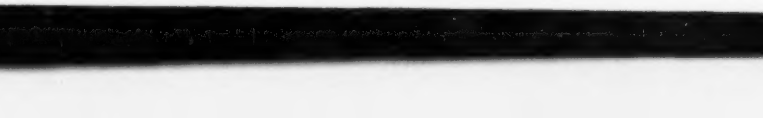

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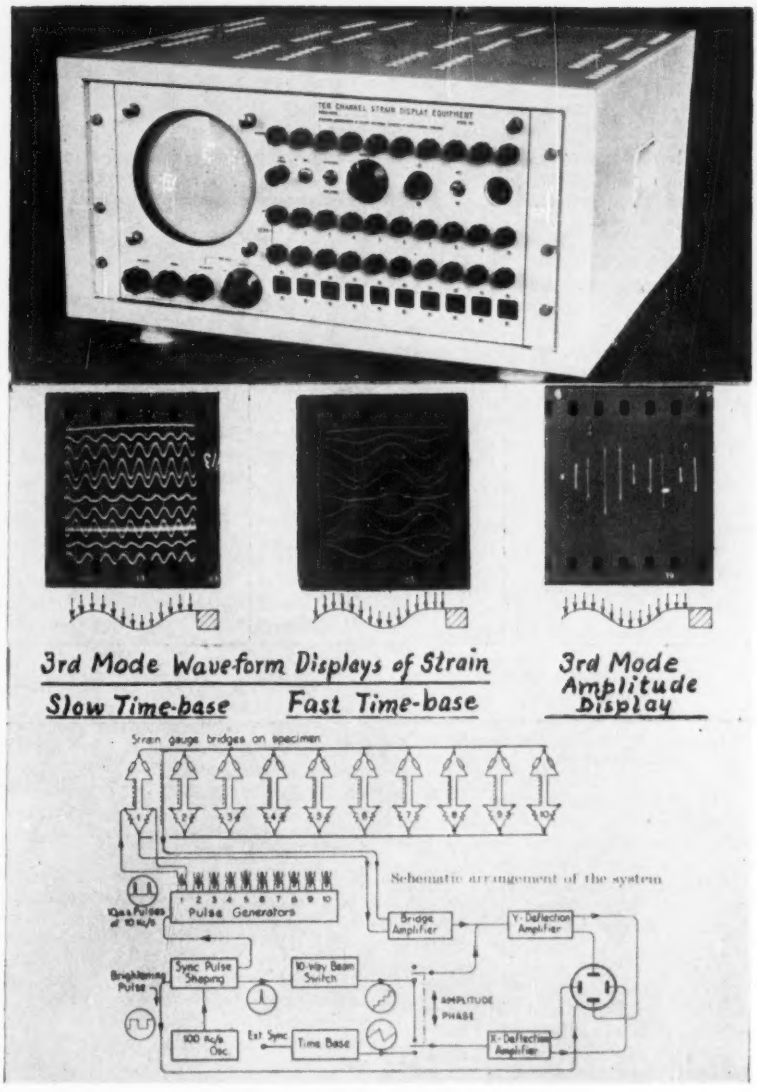

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An Analysis *of* Sphygmomanometry

By CLARKE C. MINTER, Ph.D., Washington, D. C.

This article discusses the mechanical principles involved in the operation known as "measuring the blood pressure." It is shown that the pressure which must be applied to the upper arm to stop the flow of blood in the brachial artery depends on the dimensions of the arm, the dimensions of the bone and the size and position of the artery, as well as certain physiological and psychological factors.

ONE OF THE few quantitative measurements made by the medical practitioner is that known as "measuring the blood pressure." This measurement is made with an instrument called the sphygmomanometer (literally, pulse-pressure-meter) which consists of a mercury manometer connected to a hollow flexible cuff wrapped around the upper arm and inflated. As the pressure in the cuff increases, the mercury in the manometer rises until the action of the pulse causes the column of mercury to oscillate with each beat of the heart. As the pressure is increased still further, the action of the pulse finally disappears and the mercury column no longer oscillates.

The reading on the manometer at which the action of pulse becomes evident is recorded as the diastolic pressure; and the reading at which the pulse disappears is recorded as the systolic pressure. Most practitioners prefer to inflate the cuff to a pressure higher than that necessary to cut off the pulse in the brachial artery and, as the pressure is slowly reduced, to observe: (1) the pressure at which the pulse can first be heard in a stethoscope applied below the cuff and (2) the lower pressure at which the pulse can no longer be heard.

In discussing the factors controlling this so-called blood pressure, medical men recognize that the problem has both chemical and physical aspects. Although the physical aspects include such factors as the rate and strength of the heart-beat, the viscosity of the blood and the size of the blood vessels, all the physical factors are controlled in a sense by the chemical action of hormones or internal secretions. In this article the role played by the physiological and psychological factors will not be discussed, but an analysis will be given of the mechanical principles involved in making measurements with the sphygmomanometer, with emphasis on the morphological and anatomical factors.

Morphological Factor

In discussing form and size, biologists make use of elementary geometry and algebra to express the relation between size and weight of any particular species. From geometry it is known that for similar figures the surface increases as the square, the volume as the cube, of any linear dimension. Thus if we take a sphere of diameter d, the surface will be πd^2, the volume will be $(1/6)\pi d^3$, and the ratio of volume to surface will be $(1/6)d$.

Expressed algebraically, if V is the volume and S the surface $V = k_1 d^3, S = k_2 d^2$, in which k_1 and k_2 are factors of proportionality. We have further

$$\frac{\text{Volume}}{\text{Surface}} = \frac{V}{S} = \left(\frac{k_1}{k_2}\right)\left(\frac{d^3}{d^2}\right) = Kd,$$

which states that the ratio of volume to surface is proportional to diameter.

Since the weight of an animal is proportional to its volume V, we can make use of the first equation and write $W = k_3 d^3$, which gives the weight of an animal if we take any dimension and know the factor of proportionality for that particular dimension and that particular species. Thus for humans we can say that the weight is proportional to the diameter of any member, such as the diameter of the upper arm where blood pressure is measured.

From $W = k_3 d^3$ we can write $d = k_4 W^{1/3}$ which states that any dimension such as the diameter of the upper arm is proportional to the cube root of the weight. Since the operation of measuring the blood pressure consists in compressing the flesh of the arm by applying pressure to the surface, it appears to be elementary that the ratio of the volume of the flesh compressed to the area of the surface to which the pressure is applied would be the factor which controls the magnitude of the pressure required to compress the brachial artery. That is, where everything else is assumed constant and size is the only parameter, the pressure necessary to stop the flow of blood in the brachial artery should be directly proportional to the diameter of the upper arm, or proportional to the cube root of the weight. With this relation in mind it is a simple matter to set up a table showing "normal" variations of blood pressure with weight. On page 24 of Volume 4 of the *Cyclopedia of Medicine, Surgery and Specialties* it is stated that at birth the systolic tension varies between 35 and 55 millimeters. If we take the weight at birth as the controlling factor, and assume that at birth the weight varies from 3 to 12 pounds, we can say that a new-born infant weighing 3 pounds has a blood pressure of 35 mm., while one weighing 12 pounds has a pressure of 55 mm. We can then set up our table as shown herewith.

The table tells nothing about the effect of age on blood pressure, though it is obvious that as age increases the animal grows in size and weight, and that the variation in blood pressure can just as well be due to age as to weight during the period of growth for normal individuals. The table cannot possibly show the variations between individuals of the same weight, and for that reason is only a rough approximation. In making up the table it has been necessary to make the following assumptions:

Table I

Relation Between Weight and Blood Pressure

Pounds Weight W	$W^{1/3}$	$\frac{W^{1/3}}{1.442}$	*Blood Pressure mm. Mercury* $\frac{W^{1/3}}{1.442} \times 35$
3	1.442	1.000	35
8	2.000	1.387	48.58
12	2.290	1.588	55.58
25	2.925	2.028	70.98
50	3.680	2.552	89.32
75	4.22	2.926	102.41
100	4.63	3.211	112.38
125	5.00	3.467	121.38
150	5.31	3.682	128.87
175	5.59	3.876	135.68
200	5.84	4.050	141.75

(1) That human flesh is a homogeneous isotropic material with definite physical properties (volume elasticity, modulus of rigidity, etc.) no matter what the age, the health, or the nervous state of the individual;

(2) That the dimensions of the brachial artery are always directly proportional to the dimensions of the arm;

(3) That the diameter of the arm bone is always directly proportional to the diameter of the arm; and

(4) That the position of the brachial artery relative to the bone and to the surface of the arm is always the same.

Anatomical Factors

Of course we are not justified in making any of the above assumptions. It is obvious that living human flesh differs markedly from other compressible deformable matter, and that we can treat it as such only approximately. It is also clear that such antomical factors as the size of the arm bone, and the dimensions and position of the brachial artery will differ appreciably among individuals, and the manometer readings will vary widely.

As pressure is applied uniformly at the surface of the arm, every portion of the flesh moves in toward the bone, the distance moved by any portion being directly proportional to its distance from the bone. Since the surface is farthest removed from the bone it moves the greatest distance. Likewise the top of the brachial artery moves farther inward than the bottom because the top is farther from the bone than the bottom. In this manner the brachial artery is gradually deformed and finally flattened so that blood no longer flows through. When the tissues have been brought to a certain state of compression the heart-beat will be transmitted and show up as oscillations of the mercury column of the manometer.

Sun Oil, Toledo, goes on stream with first big Houdriflow units...

... under Foxboro M-40 Control

When Sun Oil Company's new Plant 5 at Toledo, Ohio, went on stream last May, 81 Model 40 Controllers took over critical control functions. Without any manual "juggling", process variables came directly to their control points, because M-40 met the preset values so exactly. And the inherent accuracy of the M-40 *held* them there, continuously!

This first major installation of Houdriflow "cat" crackers offers another outstanding example of the petroleum industry's preference for Foxboro M-40, "the finest modern controller"!

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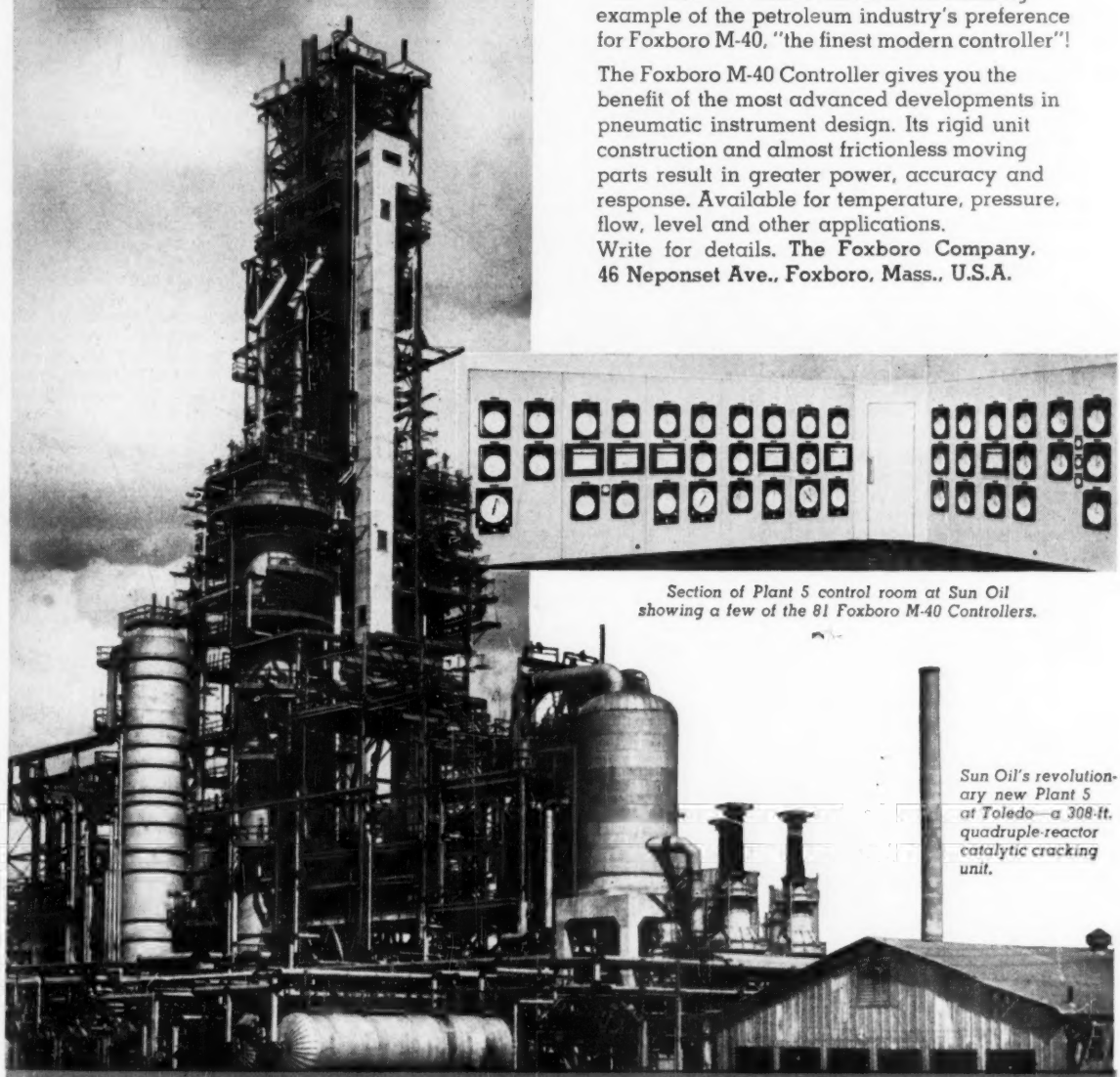
Section of Plant 5 control room at Sun Oil showing a few of the 81 Foxboro M-40 Controllers.



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The pulse thus disturbs the pressure equilibrium in the system, and the compressed flesh transmits the disturbance in much the same manner as it would any other periodic disturbance, such as sound, and the pulse shows up as oscillations in the manometer.

The equation given in Table I for the relation between blood pressure and weight,

$$P = (W^{1/3}/1.442) \times 35,$$

will have to be modified to take into account the various antomical factors. If factors for age and nervous tension are inserted, we have finally

Blood pressure =

$$KW^{1/3}\left[\frac{a-b}{t}\left(\frac{r_1-r_2}{r_1+r_2}\right)\right]A^X N^Y$$

In this relation

K = constant of proportionality
W = weight of individual
a = diameter of upper arm
b = diameter of bone
$(a = 2r_3 + b)$
t = wall thickness of brachial artery
r_1 = distance of inside bottom of artery from bone
r_2 = distance of inside top of artery from bone
r_3 = distance of outer surface of arm from bone
$(r_3 = (a-b)/2)$
A = age factor
N = neurasthenic factor

Normally the exponents X and Y of A and N should be zero, and in that case we have only the morphological and antomical factors to consider. The exponent Y can have a positive value in the case of nervous stress, but the value of Y can also be negative, as in Addison's disease or in shock.

The above relation shows that with an arm of a given diameter, the sphygmomanometer reading will be high if the bone is small, if the artery is large or has a thin wall, or is exceptionally close to the bone. To illustrate how the anatomical factors will affect the readings, or formula states that an individual with a small bone in a fat arm will show a high reading, which will be still higher if the brachial artery is exceptionally large and unusually close to the bone. On the other hand a hyperpituitary with a large armbone and a small artery close to the surface of the arm will show a low reading on the manometer.

It must be admitted that the equation given above has not been checked experimentally and that it probably is impossible to do so. However, it seems to be a sound approximation to the facts. It is hoped that this discussion will stimulate efforts to clear up some of the obscurities and doubts about the present technique. In making a blood pressure measurement, do we simply compress the flesh, using the pulse as a measure of the degree of compression, the actual result having nothing to do with the pressure of the blood in the arterial system? Or is the pressure required to compress simply a measure of the general tonus of all the muscles, including the vessels of the arterial system and the heart?

INSTRUMENTS ON THE MARCH

Diaphragm-type Micromanometer with Electrical Pick-up

Washington, D. C.—A diaphragm-type micromanometer, utilizing an electrical pick-up, has been developed recently at the National Bureau of Standards to measure differential pressures in the micron region, according to NBS Technical Report 1475. Constructed for use with a mass spectrometer, the micromanometer gives rapid, direct readings of pressure on a microammeter scale that can be calibrated directly in units of pressure. It is relatively insensitive to temperature changes, will operate in any position, and permits measurements that are totally independent of the type of gas or vapor being measured.

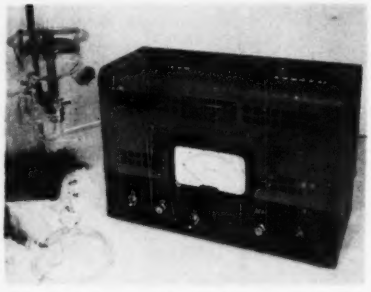

Fig. 1. Diaphragm-type micromanometer (inside bell jar, left) developed at the National Bureau of Standards to measure differential pressures in the micron region.

The need for such an instrument arises from the inevitability of error in the usual method of measuring gases for use in a mass spectrometer. A small sample is measured in an ordinary U-tube manometer and passed into the reservoirs of the mass spectrometer, where it expands to 1000 times its original volume. Its pressure is then assumed to one one-thousandth of its original pressure, but this assumption fails to account for losses that occur through adsorption of the vapor by stop-cock grease and the walls of the system, and deviation from perfect gas laws.

It is desirable, therefore, to measure the pressure of the sample in the reservoirs after the losses have occurred. Manometers for the range from one micron to 0.1 mm. of mercury are usually liquid-level devices, such as McLeod gages, or depend on thermal effects, such as Pirani or thermocouple gages. McLeod gages are accurate, but the presence of mercury or oil vapor introduces difficulties into vacuum work; besides, these instruments are bulky and inconvenient to use. Pirani and thermocouple gages, though avoiding these difficulties, are inaccurate and, unless special care is exercised, give only a rough indication of the vacuum.

The instrument developed at the Bureau consists of a pressure cell and an electrical micrometer, enclosed in a glass dome which can be evacuated or filled to any desired reference pressure. The pressure cell, the heart of the instrument, is composed of a thin corrugated diaphragm sealed at the periphery to a slightly dished brass disk. This cell is connected to the gas sample so that change in pressure of the gas causes movement of the flexible diaphragm. Movement of the diaphragm in response to pressure variations is measured by a mutual-inductance micrometer placed over, but not in contact with, the diaphragm. Mechanical coupling errors are thus eliminated.

The micrometer was previously developed at the Bureau in connection with the design of indicating devices to measure clearances in journal bearings. In principle, it makes use of the variation in mutual inductance between two concentric air-core coils which results when the distance of the coils from a nonmagnetic metal surface changes. When the metal is brought immediately adjacent to the end of the form supporting the coils, the mutual inductance is minimized by what is effectively a "shielding" action of the metal. As the metal is moved away from the coils, the mutual inductance increases as a linear function of the separation.

In the micromanometer, the metal "shield" is the diaphragm of the pressure cell itself. Radio-frequency current is fed into a primary coil and induces a voltage in a secondary coil, mounted just above the diaphragm. The form supporting the coils is mounted rigidly with respect to the fixed portion (the brass disk) of the cell. Mutual inductance between coils is therefore a func-

Continued on page 1172

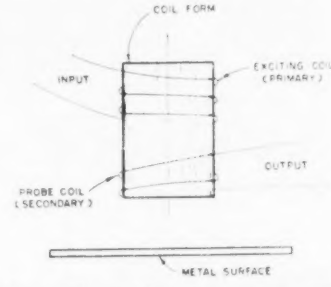

Fig. 2. The electrical pick-up of the micromanometer is a mutual-inductance micrometer. Current induced in the secondary coil is proportional to the distance from the diaphragm of the pressure cell.

CONTINUOUS ANALYZERS *Continued from page 1131*

Applied Physics Corp., Precision Scientific Co., the Dow Chemical Co., and the Mellon Institute of Research through the Office of Rubber Reserve.

CONCLUSION

In conclusion, it is considered fitting to mention some of the problems encountered in the development and in the application of continuous analysis instruments. Both instrument developments and process applications of continuous analysis techniques have been limited somewhat by the fact that industrial uses often are associated with confidential stream compositions and/or process operating variables. Usually, it is difficult and awkward and at times it is impossible for the industry research man to discuss plant applications with sufficient freedom that an instrument engineer can design and build the machine required for a specific purpose. In some instances the instrument manufacturer does not know what is needed and the application engineer does not know what can be made available in the form of finished tools for continuous analysis. Without some knowledge of potential future applications as well as specific present applications, the instrument manufacturer hesitates to enter expensive design and developmental programs for new instruments. This situation is especially true for non-dispersion type infrared analyzers. Nevertheless, some five or six different manufacturers are actively engaged in building, re-designing and/or improving this continuous-analysis instrument. Instrument manufacturers are to be commended on their farsightedness in this respect.

In my opinion, "the surface has only been scratched" in applying continuous recorder-controller analyzers to industrial processes. In the next five to ten years we are likely to see such expansions and developments in the fields of infrared, ultraviolet, mass, emission, Raman and microwave spectroscopy, plus densitometers, refractometers, viscometers, dielectrometers and conductometers that complex industrial units will be operated primarily by rapid on-the-job product quality analyzers rather than by often delayed analytical laboratory tests.

GRAPHIC PANELS *Continued from page 1129*

Now let us examine the graphic board to see what complications are encountered when changes are necessary. In the case of changing functions, such as changing a base pressure controller to a temperature controller, the change can be performed quite readily since all miniature panels are interchangeable irrespective of function. Quite frequently the same miniature panel can be left in the same location with minor changes to the symbolic piping on the panel. Modern graphic boards today do not use painted lines on the surface, but metal or plastic lines that are affixed to the board in relief. This method makes changing of the lines considerably easier than those systems requiring a paint job. In the case of additions to the existing board a somewhat more difficult problem is presented. If the addition is a minor control addition, such as a temperature controller on a preheater or a pressure controller on a surge vessel, sufficient space on the panel can usually be found for a miniature panel. If the instrumentation of an entirely new column is necessary, steps such as relocation of the board or addition at the end of the board will be necessary. This last step admittedly is an expensive venture but is no more so than that involved in a conventional type of instrument board. From this it can be concluded that graphic panels are actually easier to convert than the conventional type of control board.

The cost of installing a graphic board is a topic which has received much argument in the recent year. Some engineers maintain that they have experienced a higher cost than for the conventional board, while others state the cost is lower. Actually, both are correct. If the graphic panel is loaded with a large amount of gingerbread and decorative devices, the graphic will probably exceed the cost of a conventional panel as it is probably doing a

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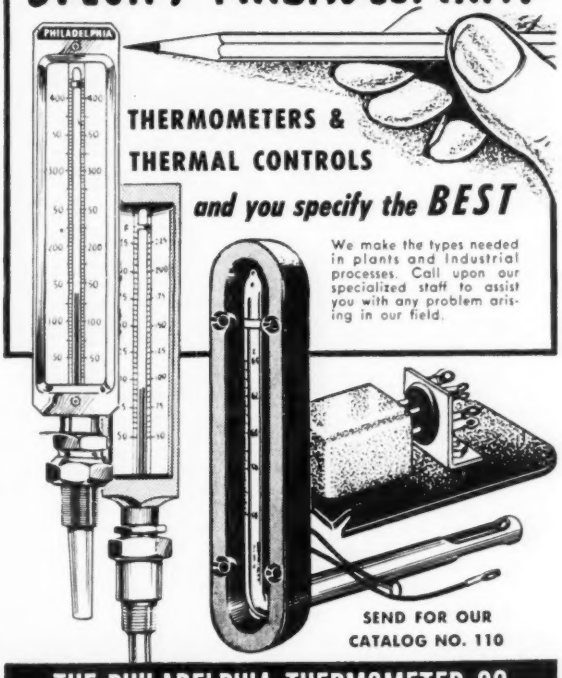

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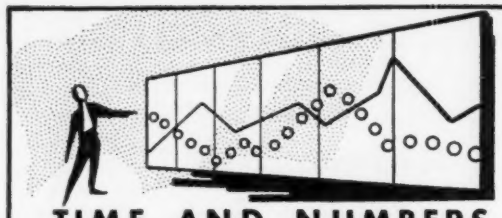

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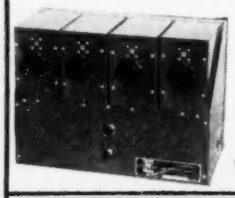

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larger job. If, however, the graphic is designed with the prime purpose of simplicity and directness of purpose with a reasonable spread of units for maximum usability and minimum board length, the graphic will usually be more economical in board lengths exceeding approximately fifteen feet. Again, this is merely a rule of thumb, and various complexities enter into the picture and one must be extremely careful to compare equivalent pieces of equipment. For example, it is unfair to compare a graphic panel with all functions being transmitted to the board with a conventional panel where no transmission is used. The argument of transmission versus direct lines is not one to enter into the pros and cons of the graphic board. That argument must be settled on its own merits. Actual installations are known where a saving of 20 to 30 percent in installed costs has been realized by the use of graphics over conventional panels.

Thus far we have been speaking of new installations only. The graphic panel has untold advantage when one has to alter existing conventional controls in limited areas. In such cases one can make additions or alterations by means of graphic panels without the addition of more control room area. Frequently this would be highly expensive and, in some cases, entirely impossible or impractical owing to present location of buildings and equipment. In such cases the cost saving becomes extremely high in favor of the graphic panel. Again, as a rule of thumb, a graphic panel can be built into approximately 50 to 60 percent of the panel board space required by a conventional control board. Installations have been known where the installation has been crowded into approximately 25 percent of the conventional panel space. This, however, becomes extremely crowded and the simplicity for which the graphic panel was designed is lost. Extreme care should be taken not to attempt any installation that will result in a crowded and jumbled board.

The chief sources of saving realized from a graphic panel come from the following:

1. Decrease in board length.
2. Decrease in control room area.
3. Decrease in operating personnel due to the smaller board area that needs monitoring.
4. Decrease in maintenance time resulting from the unitized construction of this type of control board, thus allowing for shop overhaul of the various units.
5. Decrease in down time or "off of automatic control" time resulting from a faster overhaul of instruments made possible by the interchange of units rather than the prolonged maintenance in the field on a conventional type instrument.

There exists another type of panel board which could be used but which is definitely not recommended. This control board consists of using the unitized construction of the graphic panel mounted side by side covering the entire side of the control room. In other words, the control panel would consist of a solid mass of miniature panels mounted side by side without the use of a graphic picture tying together the various functions. This type of board would utilize a minimum amount of space since the open area between the controllers normally necessary for the graphic picture would not be necessary. Although monetary advantages can be seen from this type of panel, the prime purpose of simplicity and straightforward approach is lost. The operating man would have to remember which miniature panel belongs to which function. Such an assembly would be extremely confusing to the operator and extremely lengthy to teach to new personnel. Such a board is not known to exist, but it could conceivably be designed and built. Such a system is not recommended.

In summarizing, it can be said that the graphic panel presents a clear concise picture of the process under operation in a minimum of board area. It allows rapid and clear instruction to new personnel—both operating and maintenance. It does all these things at a financial advantage in most cases. With these points in mind it is suggested that new installations or revisions be carefully studied in view of what the graphic panel may do for the proposed system.

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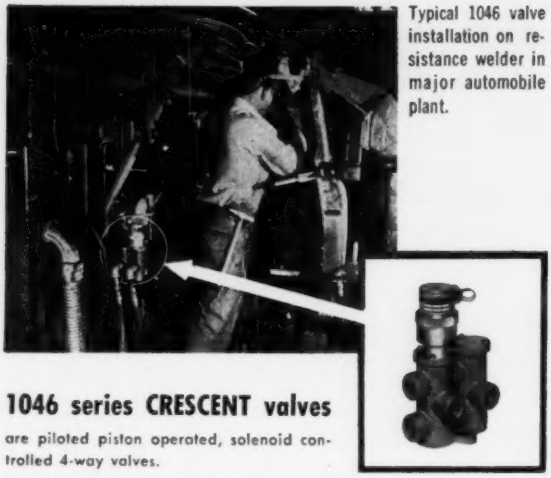

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[COVER-PICTURE STORY]

GE's New Measurements Laboratory

LYNN, Mass., Oct. 30—The General Electric Co. today officially opened its new measurements laboratory, believed to be the world's most modern and best equipped of its kind.

Staffed by engineering specialists in magnetism, electricity, chemistry, metallurgy, sound, heat, light and color, the new laboratory contains complete facilities for applied research product development and design in the field of measurements.

The five-story building contains 142,000 square feet of floor space, the major portion of which is occupied by the laboratory and associated engineering groups, the remainder by administrative staffs of the G-E Meter and Instrument Divisions.

In announcing the opening of the new laboratory, H. E. Strang, divisions manager, pointed out that "it represents the ultimate in facilities devoted exclusively to development of new measuring devices, the creation of new materials for these devices, and the critical analysis and improvement of designs already on the production lines."

"The addition of this laboratory to the West Lynn Works," he said, "clearly establishes Lynn as world headquarters for electrical measurement. Morever, it underscores the emphasis placed by the company on research and engineering leading to new and better instruments for home, science and industry."

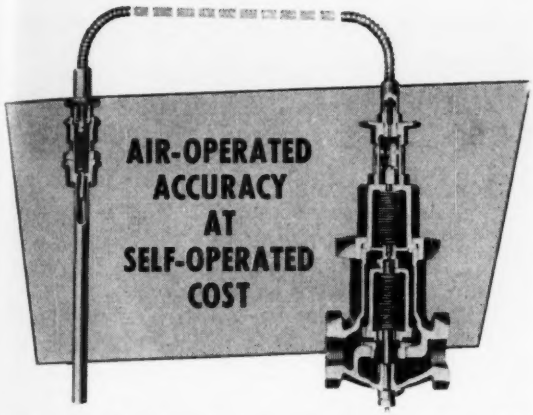
"This structure," he declared, "is dedicated to the progress of measurements, upon which man's industrial progress so largely depends." Emphasizing what he termed "the rapidly increasing significance of electrical measurement and control to industry," he predicted that the total value of measuring apparatus produced annually will rise from $600,000,000 to more than $1,000,000,000 in the next decade.

"There is virtually no limit to what instruments, some day, will be able to accomplish," he said. "Opportunities are so challenging in the measurements field that it is impossible now even to conceive what magnitudes will have to be measured, much less forecast what instruments will have to be developed to measure them. However, out of the research, analysis and development conducted in laboratories like this will be created the instruments of the future, contributing substantially to America's industrial productivity."

Two major objectives guided the company in designing and equipping the new laboratory, according to I. F. Kinnard, manager of engineering for the divisions: (1) to provide the best possible tools for the staff of more than 300 measurement specialists; and (2) to remove all physical barriers from coordination and integration of their work.

These goals were achieved, he said, by making the latest specialized laboratory apparatus and all required electrical and mechanical services readily accessible to all specialists.

Exterior view of new Measurements Laboratory of GE's Meter and Instrument Divisions at Lynn, Mass.



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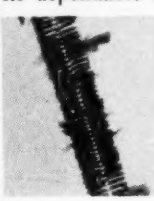

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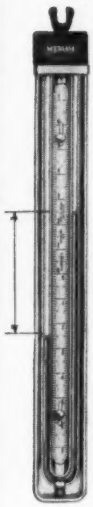

U-TYPE MANOMETERS

The Clean-Out Manometer (at left) for line pressures up to 100 lbs. per sq. in. A wing nut permits the Manometer body and tube to be disconnected from the head — the tube cleaned with a brush furnished or tube replaced, and the instrument reassembled without disconnecting the head section from the piping. Send for Bulletin No. 1.

The Model A-995 WM Manometer for line pressures up to 400 lbs. per sq. in. These instruments are built with heavy walled annealed straight Pyrex tubes, gland packed top and bottom in steel end blocks and clamped to the body at fixed intervals to prevent distortion. Catalog Sheet A-995 WM gives complete details.

WELL-TYPE MANOMETER

Model A-275 WM (at left) is a direct reading type for line pressures up to 150 lbs. per sq. in. Standard construction; ranges — from 6" to 24". Wall mounted type shown; also available in flush mounting. Ask for Catalog Sheet A-275 WM.

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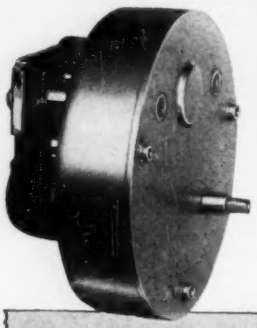

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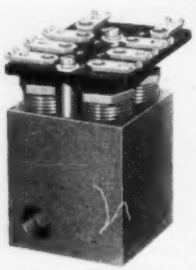

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Engineers in the new GE Measurements Laboratory put developmental instruments through electrical tests at a harmonic generator, variable frequency, and d-c. power supply control board.

and by allotting them ample space in light, comfortable, semi-private workrooms.

He pointed out that work areas for the three major functional laboratory groups—the Advanced Engineering, Materials and Processes, and General Service sections—have been allotted on the basis of their special space and equipment requirements, and to assure the free flow of ideas and information among them.

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A standards expert works with a comparison bridge for measuring standard resistors in the new GE Measurements Laboratory.

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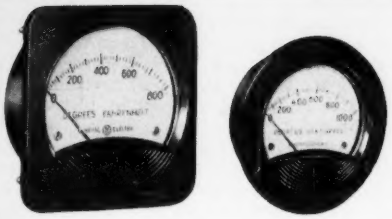

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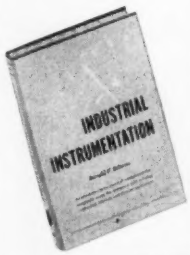

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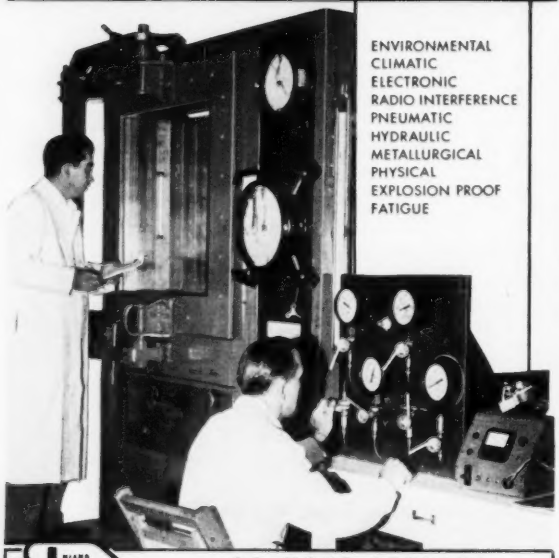

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When required, laboratory specialists can "hook in" electric power from any part of the laboratory by means of an intricate tie-line system which, according to Kinnard, makes possible the remote testing of instruments and does away with time-consuming shifting of test apparatus.

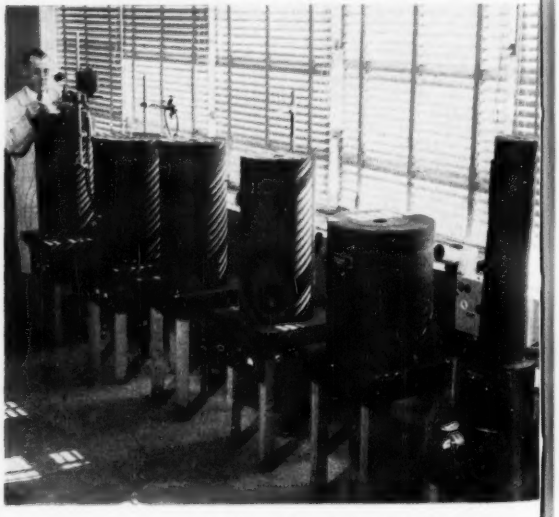
The Advanced Engineering sections, responsible for mechanical and electrical development associated with watt-hour meters, demand meters, instrument transformers, electric measurements of all kinds, aircraft instruments and time switches, occupy more than one floor of the laboratory proper. Adjacent to individual cubicles are small-scale machine shops equipped with machine tools for the construction of "bread-board" models of new instrument designs.

The Materials and Processes sections develop and evaluate the new materials which permit development engineers to expand their horizons to new measurements and new concepts of measurement devices. A metallurgical laboratory, equipped with metallographic-, radiographic-, tensile- and hardness-testing equipment, enables specialists to "see into" metals and metal-alloys to determine their physical and electrical properties. In another area, special furnaces permit the development and evaluation of the properties of measurements alloys as they are treated under wide ranges of temperature.

To keep a constant check on the calibration of testing equipment, a set of primary standards, equivalent to those at the National Bureau of Standards in Washington, D. C., is maintained at the laboratory. The applicable standards include time, temperature, resistance, and volts.

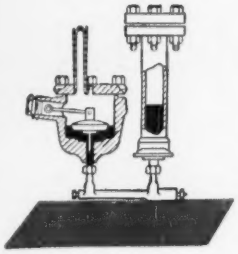
A battery of specially-constructed baths house primary standards of temperature. The standard cells used to maintain the value of the volt are contained in a heavily-insulated oil bath held at constant temperature. Standard ohmic resistances are similarly maintained.

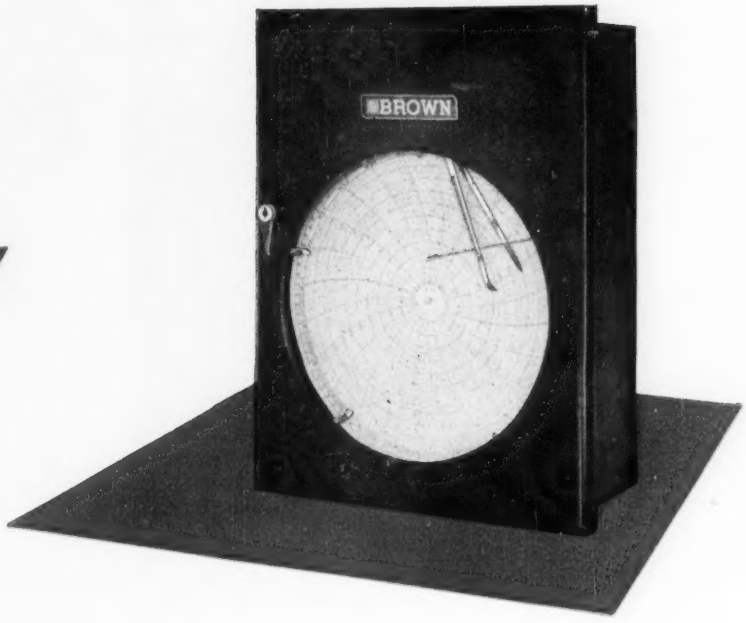
These primary standards form the reference from which the calibration of intermediate standards are derived. These intermediate and working standards, for example, are used to calibrate the actual resistors, shunts, potentiometers, volt-multipliers, ammeters, voltmeters, wattmeters, and the host of other instruments used for the final calibration of measurement apparatus made by the divisions.



To keep a constant check on the calibration of testing equipment, a set of applicable primary standards, equivalent to those of the National Bureau of Standards, is maintained at the new GE Measurements Laboratory. Here a calibration expert checks a temperature instrument against one of six baths which house primary standards of temperature.

THE PRESSURE GAUGE





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Rate-mode Electric-type Automatic Controllers

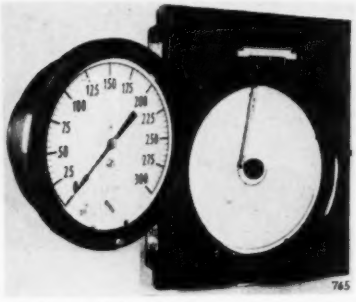
New "P.A.T. '50" electric control mechanism incorporates rate action in addition to proportional and reset actions. Rate action produces control

response related to speed of controlled-variable change. New control unit electrically links maker's potentiometric controller with electric valve-drive mechanism.—*Leeds and Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.*

Mention No. 1301 when filling out card.

Temperature Indicators and Recorders

New "Microsen" thermocouple temperature instruments use maker's "Microsen Balance" electromechanical unit. Force on beam developed by thermo-



couple emf. is balanced by calibrated spring connected to servo-driven pointer or pen. Cross range time is 3 sec.; cold junction is thermostated; adjustment for thermocouple resistance is provided. Instruments operate from 115-v. 60-cps. line.—*Manning, Maxwell, & Moore, Inc., Bridgeport 2, Conn.*

Mention No. 1302 when filling out card.

Dynamic Analyzer

New "Model 100-A" dynamic analyzer functions by injecting periodic perturbation signals into error channels of device under test, together with sweep and comparison voltages with which to view output on CRO. Waveshapes are generated by electromechanical elements geared together and driven by a precision speed control.

Range of modulating frequencies is from 0.1 to 50 cps. for transfer function tests. Phase measurements can be made with accuracies of 2 deg. For transient tests, damped natural frequency and height of first overshoot can be measured.—*Industrial Control Co., 1462 Undercliff Ave., New York 52, N. Y.*

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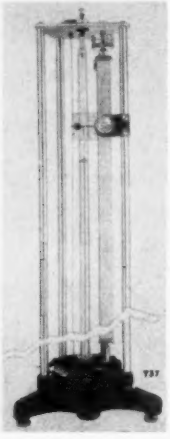
Calibrating Standard for Pressure Instruments

New "Type FA-87" precision manometer is designed for absolute or differential pressure measurement. Range is 0 to 800 mm. Hg or equivalent.



Magnetic vernier permits reading to 0.01 mm. Hg, with an accuracy of 1 part in 5000. Tension adjustment on plastic manometer scale compensates for temperature changes and corrects for gravity. A mercury valve seals top of glass manometer tube for use as absolute pressure indicator. A magnifier mounted on support post may be focused anywhere on scale.—*Wallace & Tiernan Products, Inc., Belleville, N. J.*

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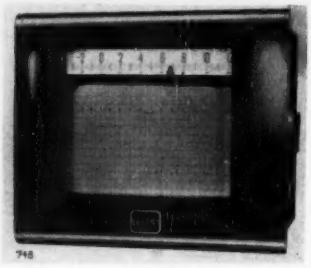
Self-balancing Recording Potentiometers and Bridges

New "Series 500 Strip-Chart Dynamaster" instruments are high-speed, self-balancing a-c. bridges for measurement of temperature, resistance,



conductivity, strain, position, inductance, pressure, force, or other variable measured in terms of impedance. Record is printed on a chart 11.25 in. wide; up to 16 points can be recorded. Models are offered for full-scale pen travel in 7, 3 and 0.67 sec.; chart speeds from 1 in. per hr. to 120 in. per min. Instruments are housed in dust-proof case suitable for wall or flush mounting.—*The Bristol Co., Waterburg 20, Conn.*

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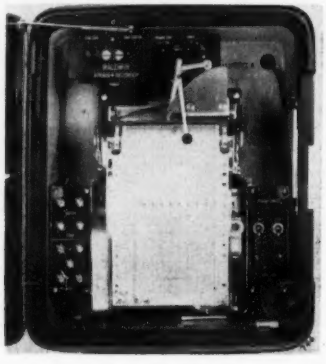
Strain Recorder

New strip-chart strain recorder is an electronic type instrument calibrated for use with two SR-4 gages having a resistance of 120 ohms and a sensitivity factor between 1.9 and 2.2.

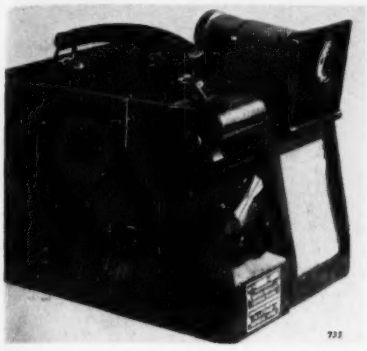


Available ranges are 0-2000, 0-5000, and 0-10,000 microinches per inch. Ten chart speeds from 0.75 to 720 in. per hr. are provided. Pen moves across a 4.5 in. chart in a straight line; full scale traverse speeds of 1, 3 or 5 sec. are available.—*Baldwin Locomotive Works, Philadelphia 42, Penna.*

Mention No. 1306 when filling out card.

Square-coordinate Pen-type Oscillograph

New pen-type oscillograph has frequency range from 0 to 600 cps.; measuring range between 5 and 160 v., or 2 and 60 ma. Sensitivity is 0.1 mm. per

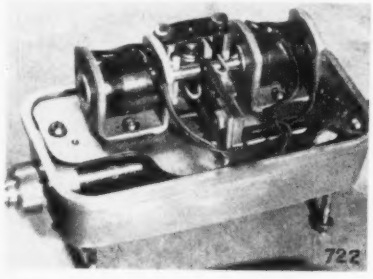


volt; impedance 2700 ohms. Unit has 10 paper speeds. Pen is automatically closed when not in use. Record is made on transparent chart paper in straight-line rectangular coordinates; maximum amplitude is 60 mm. Over-all dimensions 10 x 8 x 7 in.; weight 13 lbs.—*Sound Apparatus Co., Stirling, N. J.*

Mention No. 1307 when filling out card.

Low-speed Motor Servomechanism

New "Magnerotor" low-speed motor produces high starting torque, can be reversed, and has variable speed. Makers can supply speeds from 0.5 rpm. to 100 rpm. (no reduction gears needed) in either unidirectional or reversible models operating on 6, 24, 115, or 220 volts; 60-cycle a.c. It is said that, owing to motor's unique construction, exceptionally high starting torque is obtained. For example, at 35 watts input, starting torque at 1 rpm. is 80 in.-lbs. Standard model



has a weatherproof die-cast housing (photo shows cover removed), requires no oiling and is said to operate "at extremely high and low temperatures under extreme weather conditions." It can be remotely controlled in same way as servomechanisms. For example, operator can set his control dial for any desired position, and motor will turn clockwise or counterclockwise as desired and come to a stop in position set on control dial.—*The Viking Tool & Machine Corp. 2 Main Street, Belleville 9, N. J.*

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Voltage	26-volts, single-phase	26-volts, single-phase	26-volts,single-phase
Frequency	400 cycles per second	400 cycles per second	400 cycles per second
Current	105 milliamperes	130 milliamperes	155 milliamperes
Power	0.90 watts	1.4 watts	1.9 watts
Impedance	85+j240 ohms	80+j180 ohms	77+j149 ohms
OUTPUT			
Voltage max. (rotor output)	18.0 volts	15.5 volts	13.3 volts
Voltage at null	30 millivolts	20 millivolts	20 millivolts
Sensitivity	315 millivolts/degree	270 millivolts/degree	230 millivolts/degree
Voltage phase shift	18.5 degrees	24.5 degrees	28.0 degrees
System accuracy (max. possible spread)	0.5 degrees	0.5 degrees	0.5 degrees

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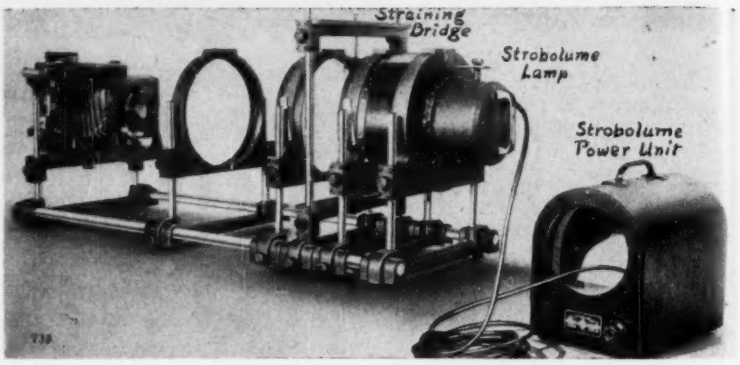


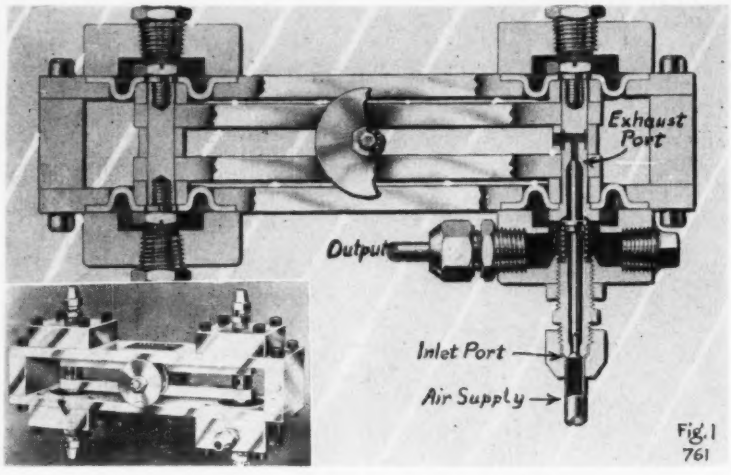
Dynamic Stress Polariscope

New "Type 1534-A" polariscope comprises a diffuser, polarizer, model mounted in straining bridge, analyzer, and camera bridge. Diffuser accepts either a Strobolume lamp, or incandescent light. Polarizer-analyzer assemblies are identical; both mount rotatable plane polarizer and quarter-wave retardation plate, registering for right- or left-hand circular polarization. Camera is not included.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

Mention No. 1309 when filling out card.

Pneumatic Totalizer and Control-action Generator

New "Ratio Totalizer" combines two or more pressures (or other signals) in any desired ratio to produce a single output pressure. It may be used to add, subtract, multiply or divide control signals in computing circuits, or to introduce proportional or rate action or automatic reset, either separately or in any desired combination, in control circuits. Two or more may be connected pneumatically to combine control actions. Standard model (Fig. 1) comprises four pressure chambers arranged in opposing pairs and acting through non-metallic flexible diaphragms on ends of a balance beam whose fulcrum is adjustable to give beam-arm ratios from 1:1 to 16:1 (For control, a proportional band of 25 percent to 400 percent.) Any of input pressure may be replaced by an attachment (Fig. 2) for measurement of a mechanical force; or modified by use of tension springs (Fig. 3) or metal bellows (Fig. 4). A single spring may be used as a fixed loading for manual set-point adjustment or as a bias in connection with signals requiring range suppression. Maximum spring load is equivalent to 60 psi. pressure, which is maximum allowable pressure in standard pressure chambers. Bellows elements permit use of Totalizer for measuring fluid pressures higher than usual pneumatic loads, and up to 600 psi. Feature is poppet type pilot valve used to regulate output pressure. One end of valve stem normally closes exhaust port by contact with a valve seat on balance beam; other end is normally spring-held against valve seat of air supply inlet



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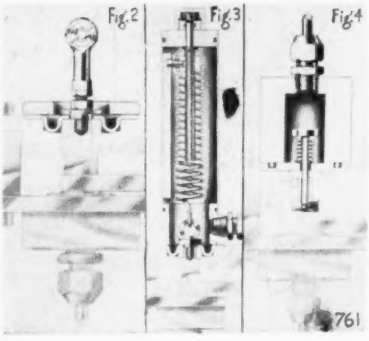
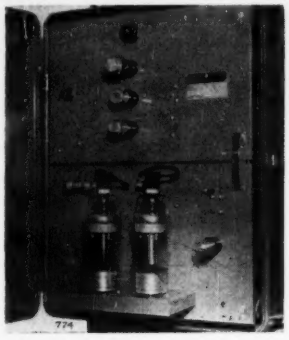


port. Movement of beam, in response to changes of input loading pressures in the other three pressure chambers, opens one or the other of these ports until forces are rebalanced. Valve is a non-bleed type which takes air only when output loading pressure is increasing. Its capacity is 2 scfm. at midpoint of operating range; average air consumption is 0.25 scfm. Output loading pressure may be in range of 3 to 15, 0 to 30, or 0 to 60 psi. Accuracy is within one percent of full-scale reading. Loading pressure is reproducable upon a change in input loadings of less than 0.1 percent, when output pressure is at maximum value. Unit is 9½ in. long over-all and centers of pressure on balance beam are 6 in. apart. Maximum adjustment range of the fulcrum is 4.375 in.—*Hagan Corp., Hagan Bldg., Pittsburgh* 30, *Penna.*

Mention No. 1310 when filling out card.

Side Register Control

New side register control consists of a rotary lens web scanner, and a thyratron control panel. Scanner features a tilting mounting bracket with adjust-

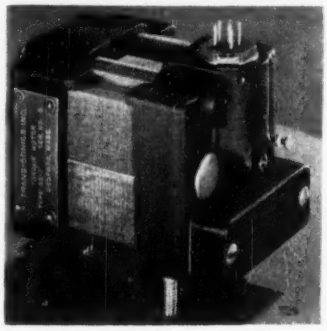


able stops to allow operation on either diffused or specular scanning. Direction of scanning can be selected, and red- and blue-sensitive phototubes furnished will handle most color contrasts. Thyratron reversing control feeds power to correction motor proportional to error detected by scanner.—*Control Divisions, General Electric Co., Schenectady* 5, *N. Y.*

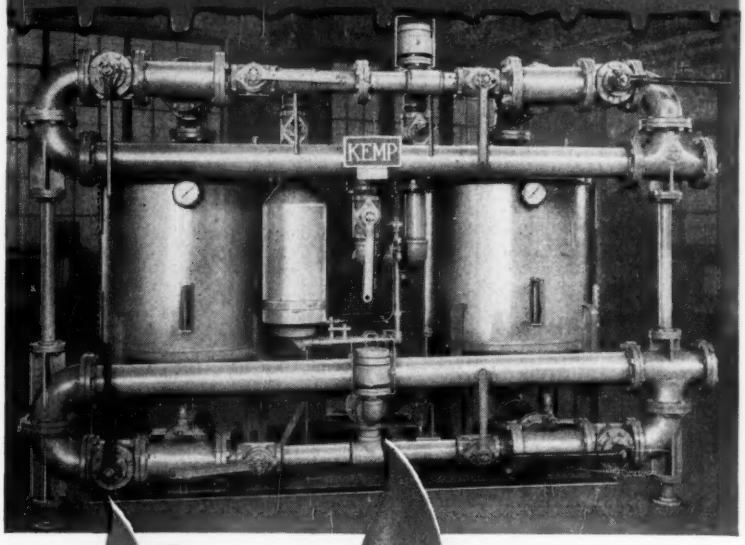
Mention No. 1311 when filling out card.

Torque Motor

New "Type 35" torque motor provides a total linear motion of 0.008 in. and moves 0.001 in. per ma. input. Locked rotor force output is 4 lbs. for a differential current of 5 ma. When



STOP MOISTURE DAMAGE



Rust and Corrosion spell death to accuracy. Read how this watch manufacturer* eliminated these hazards!

MOISTURE FORMATION . . . like that which damages your instruments . . . once forced a famous watch manufacturer *to scrap precision parts* worth thousands of dollars each week. Part of the solution was a Kemp Dynamic Dryer to dry compressed air to a final dew point of 0° F. Now, the moisture problem is gone and production increased!

SIMPLE OPERATION

Kemp Dynamic Dryers are flexible . . . offer *manual, semi-automatic* or *automatic* operation. Desiccant is especially selected and compounded for the particular duty. Units are available for drying *air, gases* or *liquids* . . . for controlling humidity in large or small areas. Choose gas, electric or steam regeneration . . . with or without cooling units.

GUARANTEED PERFORMANCE

No matter what your moisture control problem may be . . . specify Kemp first. Chances are there is a standard design that will be ideal for your plant . . . and at the same time save you money! Performance to your specifications is guaranteed! For full information mail coupon for special bulletin. *names on request

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405 E. Oliver St., Baltimore 2, Md.

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Company .....
Address .....
City ..... Zone ..... State .....

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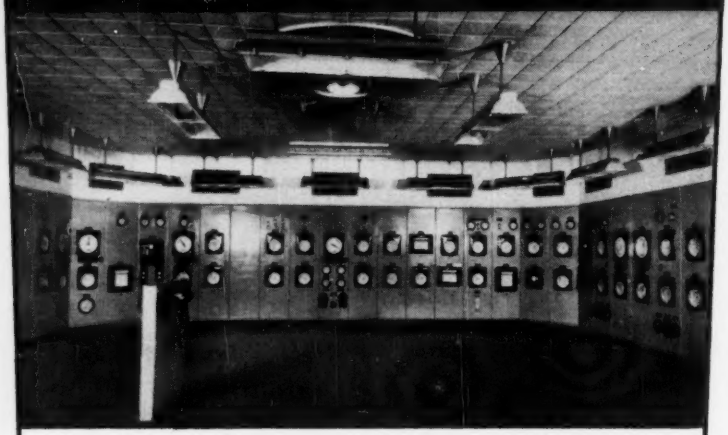
FOR SHEET METAL ENCLOSURES



If you need an enclosure for one, two or three instruments . . . or hundreds of instruments, call on KIRK & BLUM for fast, accurate fabrication. The photo above shows a typical large installation. Almost 100 instruments and controls are visible in this installation in a major refinery.

KIRK & BLUM is equipped and experienced to fabricate one unit or hundreds, specializing in custom-built parts and assemblies of sheet steel, light plate, stainless, aluminum, monel and other alloys in gauges 3/8" and lighter.

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used with a normal pilot-valve load (0.02 lbs.), device has a response time of 1 millisecond. Input may be connected directly to plate circuit of a push-pull amplifier, and a pair of subminiature vacuum tubes are sufficient to provide full output from motor. Weight 17 oz., volume 12 cu. in.—*Trans-Sonics, Inc., Bedford Airport, Bedford, Mass.*

Mention No. 1312 when filling out card.

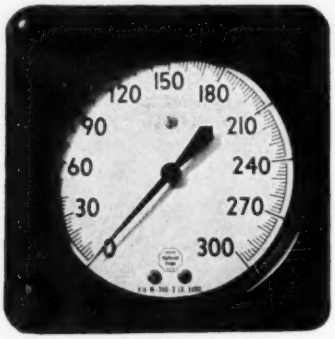
Air-operated Indicating Temperature Controller

New "No. 1600" air-operated controller features a built-in air filter which can be readily cleaned or replaced. A variety of temperature ranges, and choice of bulb and capillary construction, are available.—*Scientific Instrument Co., 1041 2nd Ave., Detroit 26, Mich.*

Mention No. 1313 when filling out card.

Square Flush-case Pressure Gage

New square gage case for flush-mounting has same bolt-circle and panel cut-out as maker's round-case instruments. Available in 4.5, 6, and 8.5 in. dial sizes.—*Helicoid Gage Div., American Chain and Cable Co., Inc., Bridgeport 2, Conn.*

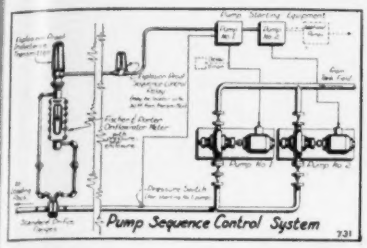


Mention No. 1314 when filling out card.

Pump-sequence Controller

New "Ori-Flowrator" pump-sequence control system starts and stops pumps as flow demand changes. Inductance transmitter on maker's area-type flow-

meter has coils set at desired pump cut-in points. Armature passing through coils changes impedance in thyratron

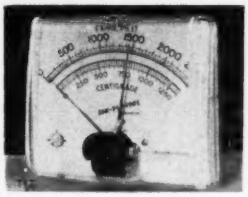


tube circuits, which operate pumps. First pump can be manually, or pressure-switch operated.—*Fischer and Porter Co., Hatboro, Penna.*

Mention No. 1315 when filling out card.

Contact-making Electrical Indicating Instruments

New "Model 451-C" contact-making instruments are 4.5 in. size of maker's "Simplytrol" line, available for measurement of a-c. and d-c. voltage and

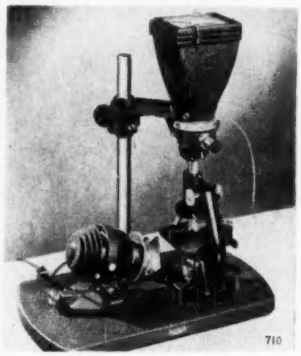


current. Contacts, when touching, are locked by magnetic action; are released by manual or automatic interruption of locking circuit.—*Assembly Products, Inc., Main at Bell St., Chagrin Falls, Ohio.*

Mention No. 1316 when filling out card.

Photomicrograph Cameras

New photomicrographic cameras are available in 35 mm. and 4 x 5 in. with universal shutter and telescopic focusing eyepiece, and 4 x 5 in. with Alphax



shutter. Image may be viewed in telescope until shutter is released. Camera may be swung away from microscope without disturbing focus; revolving body permits 360 deg. rotation of camera back. Holders are available for

Timing Ideas

WHEN TIMING COUNTS

You can always count on Haydon to provide the right motor for your timing job. Timing Headquarters offers a broad line of efficient, economical timing motors and timers produced by specialists who have no other interest than to provide the best in timing.

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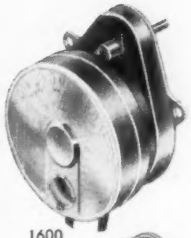
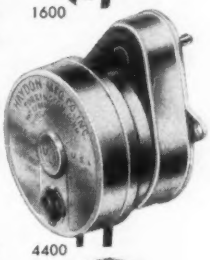


1600

COMPACTNESS AND SLOW SPEED—4400 SERIES: Designed for small size and low cost in applications requiring slower speeds from 6 hours to 7 days per revolution.



4400

HEAVY DUTY DEPENDABILITY—3100 SERIES: For control and instrument applications that require a heavy duty train and speeds from 1 hour to 14 days per revolution.

SUPERIORITY FEATURES Slow (450 rpm) rotor speed makes for quiet operation and long life. Unusually small. All motors totally enclosed. Separate rotor and reduction gearing lubricating systems permit selection of best methods and lubricants, control circulation, insure against leakage. Operates continuously in any position. Simple to mount, entire face of motor can be supported securely against mounting surface. Standard, interchangeable design in only 2 motor series with speed range from 300 rpm to 1 revolution in 7 days.

3100

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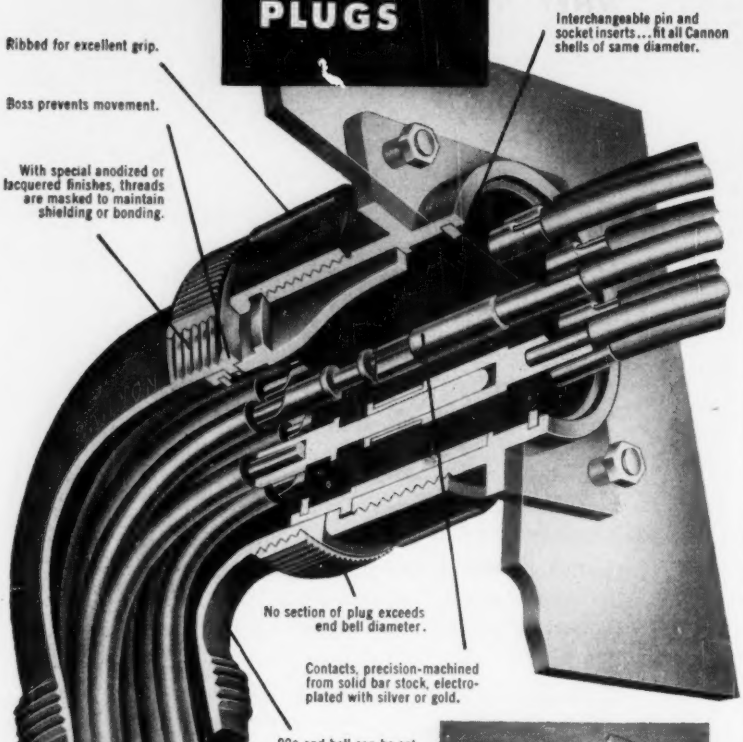
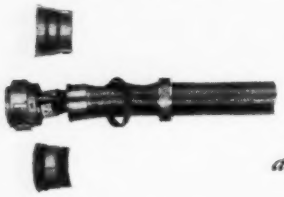

Ribbed for excellent grip.
Boss prevents movement.
With special anodized or lacquered finishes, threads are masked to maintain shielding or bonding.
Interchangeable pin and socket inserts... fit all Cannon shells of same diameter.
No section of plug exceeds end bell diameter.
Contacts, precision-machined from solid bar stock, electro-plated with silver or gold.
90° end bell can be set at 60° interval.

Type AN Connectors are made in 6 styles; straight and 90° cord plugs; box, wall, and extension cord receptacles; and special quick disconnect plugs. Fifteen diameters for inserts with contact arrangements from single to 100 contacts. Contact capacities from 5 to 200 amps. Peak voltages from 70 to 9,000 volts.



Cannon split-shell design advantages

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- end bells are interchangeable
- no slack in lines
- test without disengaging plug
- easy inspection and circuit changes

See that your circuit requirements are met. See that all control, communication and power circuits have firm positive contact, low dielectric loss... and see that each circuit is protected by the design advantages found only in Cannon Plugs. AN Connector Series is just one of the many Cannon types—world's most complete line. Request bulletins by required type or describe the connector service you need.

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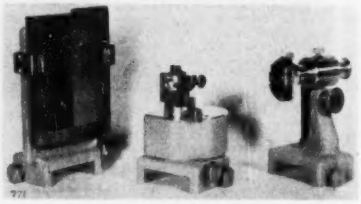
plates, films, and film packs, in various sizes.—*American Optical Co., Instrument Div., Buffalo, N. Y.*

Mention No. 1317 when filling out card.

Flat-plate X-ray Diffraction Camera

New flat plate camera is designed for 3.25 x 4 in. film, and a removable mask is used to record comparison patterns on same film. Samples requiring motion

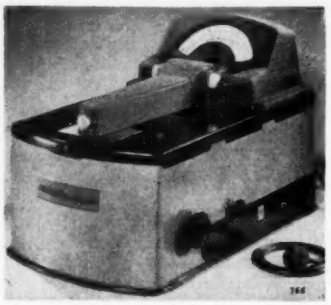


are held in motor-driven sample holder; those not requiring motion are held in auxiliary holders attached to collimator, which has lateral adjustment to obtain maximum beam intensity. Gages are provided for setting film-to-sample distance.—*Central Research Laboratories, Inc., Red Wing, Minn.*

Mention No. 1318 when filling out card.

Photometric Densitometer

New "Model 12" reads color densities up to 3.0, black-and-white to 6.0 Knob selected filters transmitting at 436, 546, and 644 millimicrons are housed in

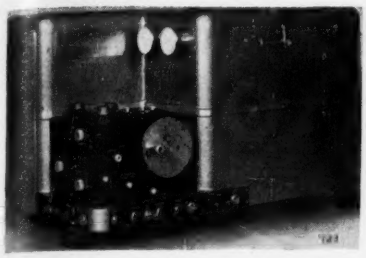


measuring arm. Electronic photometer circuit operates from photomultiplier tube, with dynode voltage feedback. Instrument is accurate within 0.02. Measuring arm covers material up to 22 in. wide, can be detached for remote use.—*Macbeth Corp., P. O. Box 950, Newburgh, N. Y.*

Mention No. 1319 when filling out card.

Double Monochromator

New double monochromator produces monochromatic radiation in spectral range from 1400 Angstroms to 25 microns, in overlapping steps, using interchangeable optical elements. Controls include handwheel for wavelength carriage drive; angular adjustment of carriage motion to compensate for focal curves of different optical materials; and adjustment of entrance, center, and exit slits. An external shaft provides wave-length carriage position

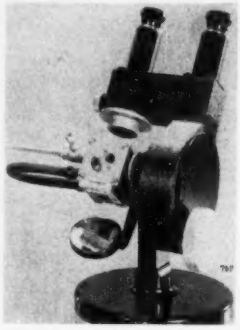


take-off for driving recorder chart. Over-all dimensions 25.5 x 15 x 13.5 in.; weight 160 lbs.—*Central Research Laboratories, Inc., Red Wing, Minn.*

Mention No. 1320 when filling out card.

Refractometer

New "Model G" Abbe refractometer has scales for refractive index from 1.3 to 1.7, dry solids from 0 to 85

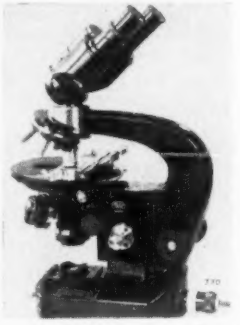


percent. Telescope for observing border line and reading microscope are side by side.—*Scientific Instruments Div., Ercona Corp.,* 527 *Fifth Ave., New York* 17, *N. Y.*

Mention No. 1321 when filling out card.

Binocular Microscope

New "Lumipan" binocular microscope has illuminator built in base. Substage has triple condenser, which permits

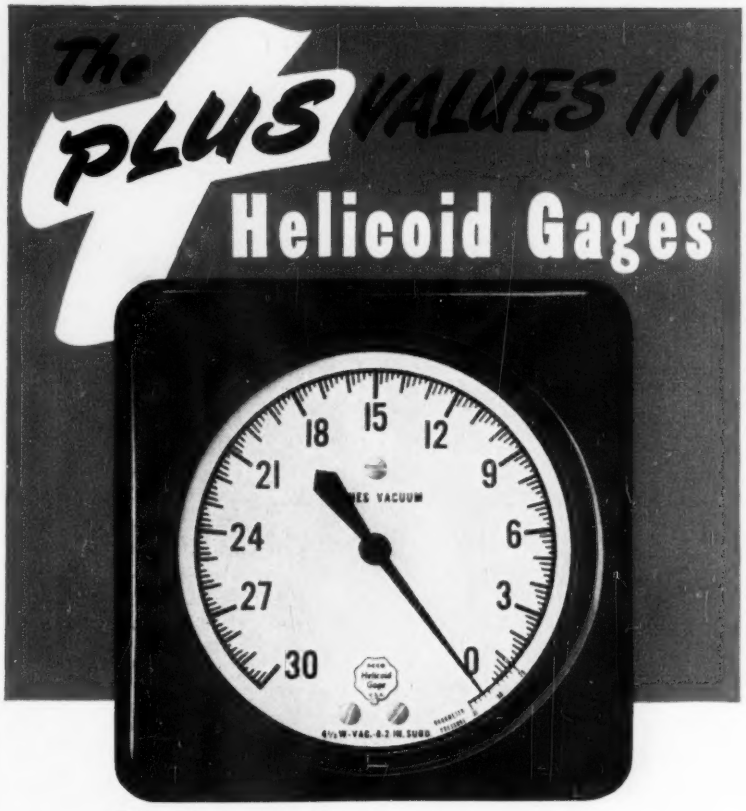


adjustment of light path. Instrument may be used for phase contrast observations.—*Scientific Instrument Div., Ercona Corp.,* 527 *Fifth Ave., New York* 17, *N. Y.*

Mention No. 1322 when filling out card.

Filmstrip Projector

New "Educator 150 Delineascope" is designed for projecting filmstrips and 2 x 2 in. slides. Change from slides to filmstrip or vice-versa is accom-

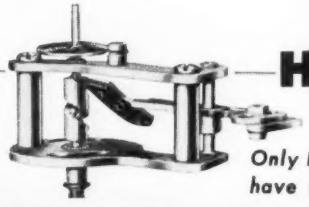


This Vacuum Gage is an example of the extra value at no extra cost in all HELICOID GAGES.

Note:

1. Dial in inches of mercury vacuum, reading counter clockwise, to denote negative pressure and prevent confusion with a 30 lb. pressure gage.
2. Subdivisions in graduated steps of 0.2 inches for ease in reading scale.
3. Hairline Pointer adjuster to correct zero setting for changes in barometric pressure.
4. Guaranteed accuracy to within 0.15".
5. The new square flush case.

Another Helicoid *"first."*



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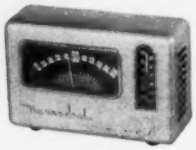

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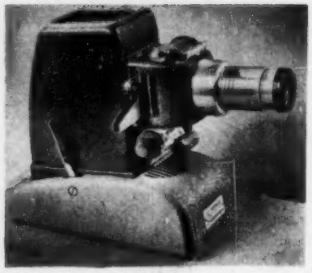
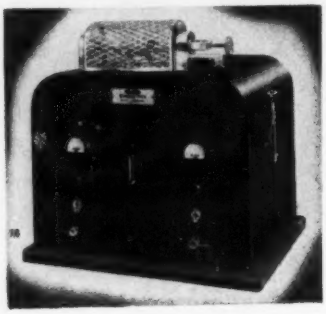


plished by removing or replacing filmstrip unit. High light output is achieved from a 150-watt bulb and two-element aspheric condensing system. Three objectives are available—3.5 in., f/3.5; 5 in., f/3.75; 7 in., f/3.65; all are achromatically and anastigmatically balanced.—*Instrument Div., American Optical Co., Buffalo 15, N. Y.*

Mention No. 1323 when filling out card.

Carbon Determination Apparatus

New "Combustron" uses induction heating; control panel includes grid and plate milliammeters, oxygen flowrate meter, and control valve. Com-



bustion and flushing are completed in 2 to 3 minutes; gravimetric or volumetric combustion trains may be used. One- or two-tube models are available for either 115 or 230 v., 60 cps.—*Burrell Corp., 1942 Fifth Ave., Pittsburgh, Penna.*

Mention No. 1324 when filling out card.

Metallograph

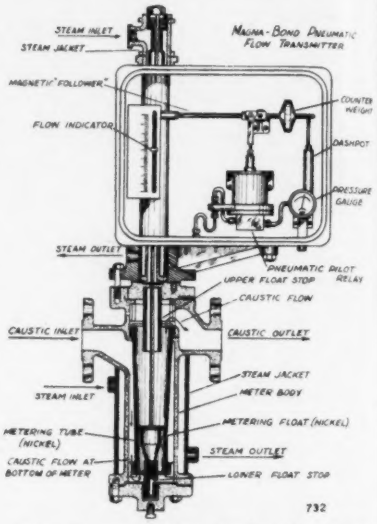
New metallograph provides camera and monocular or binocular microscope, with optical systems coupled to permit focusing through visual system. All controls are operable from sitting posi-

tion. Magnifications range from 50× to 1500×, with 2000× available. Visual and arc lamps are supplied; Graflex camera back uses double plate holders. —*Instrument Div., American Optical Co., Buffalo, N. Y.*

Mention No. 1325 when filling out card.

Caustic Soda Flowmeter

New "Flowrator" area-type flowmeter for caustic soda service has all-nickel parts in contact with fluid. Liquid

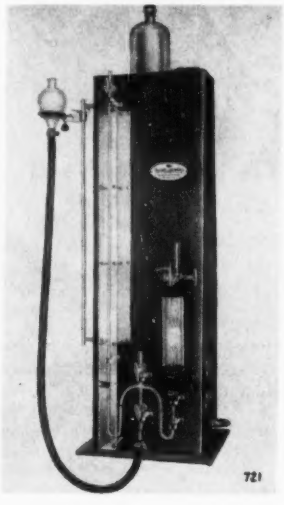


passages are steam jacketed. Meter sizes available from 0.5 to 300 gpm.—*Fischer and Porter Co., Hatboro, Penna.*

Mention No. 1326 when filling out card.

Van Slyke Blood Gas Apparatus

New Van Slyke apparatus is improved model for determination of dissolved gases in blood and other solutions, by vacuum extraction. Arbitrary sample volume is measured by manometer pressure; continuously variable stirring speeds are provided. Samples are adjusted by micrometric



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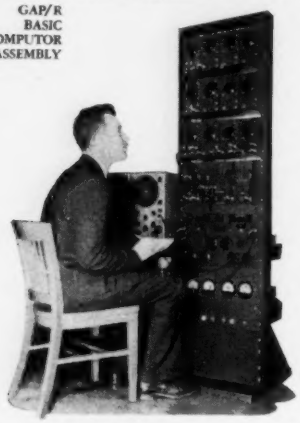


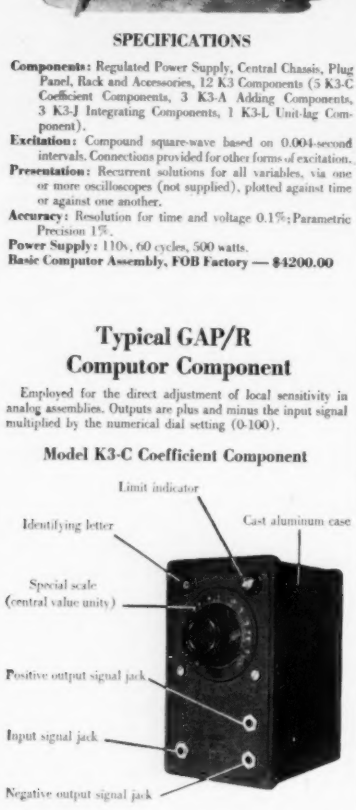
SPECIFICATIONS

Components: Regulated Power Supply, Central Chassis, Plug Panel, Rack and Accessories, 12 K3 Components (5 K3-C Coefficient Components, 3 K3-A Adding Components, 3 K3-J Integrating Components, 1 K3-L Unit-lag Component).
Excitation: Compound square-wave based on 0.004-second intervals. Connections provided for other forms of excitation.
Presentation: Recurrent solutions for all variables, via one or more oscilloscopes (not supplied), plotted against time or against one another.
Accuracy: Resolution for time and voltage 0.1%; Parametric Precision 1%.
Power Supply: 110v, 60 cycles, 500 watts.
Basic Computor Assembly, FOB Factory — $4200.00

Typical GAP/R Computor Component

Employed for the direct adjustment of local sensitivity in analog assemblies. Outputs are plus and minus the input signal multiplied by the numerical dial setting (0-100).

Model K3-C Coefficient Component



This component is one of a dozen similar types which are available from stock. Each performs a specific dynamic or mathematical operation, and is specially engineered to play its part most efficiently in any computing assemblage. Convenient to use, economical to buy, and of wide applicability, our GAP/R Analog Computor Components are now assisting study and development programs in many different fields. Is it not probable they can help you too?

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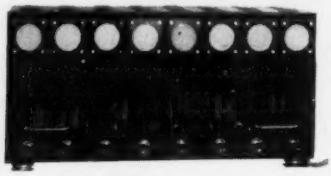
230 Congress St., Boston, Mass.

positioning of leveling bulb. Clear plastic shield protects manometer, and scale is illuminated by diffused fluorescent light.—*Emil Greiner Co., 20-26 No. Moore St., New York 13, N. Y.*

Mention No. 1327 when filling out card.

Eight-channel Seismographic Oscilloscope

New "Model H-81," developed to answer a government agency's seismographic problems, is said to enable users to learn more about Earth's characteristics than possible with magnetic seismograph. It consists of eight independent channels, each of which

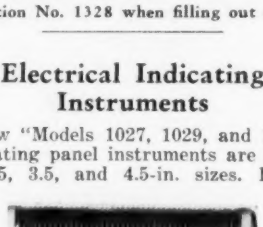


contains a single-gun cathode ray tube, RMA "Type 3 JP11"; and eight a-c. amplifiers with a deflection sensitivity of 10mv./in. Frequency response is 20 cps. to 25,000 cps. ± 2 percent or 20 to 150,000 cps. ± 30 percent. A d-c. model eight channel oscilloscope, "Model H-82," has been constructed also with a sensitivity of 2 mv./in. Factors common to all channels are intensifying of cathode-ray tubes and timing marker injection. Signals are displayed on a horizontal axis for photographing on a film strip or drum with vertical travel. Power supply is independent of indicator unit.—*Electronic Tube Corp., Philadelphia 18, Penna.*

Mention No. 1328 when filling out card.

Electrical Indicating Instruments

New "Models 1027, 1029, and 1127" indicating panel instruments are made in 2.5, 3.5, and 4.5-in. sizes. Large



scale said to be readable under all light conditions. Etched face extends across entire front of instrument; is protected by unbreakable plastic.—*Simpson Electric Co., 5200 W. Kinzie St., Chicago, Ill.*

Mention No. 1329 when filling out card.

Bolometer Bridge

New "Type 1651-A" bridge measures RF power by dissipation in bolometers with resistance between 25 and 400 ohms. Current range is 0-100 ma.;

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RECORDING GALVANOMETERS

The Century Model 210 Galvanometer has been designed and tested for the utmost in performance under any conditions. The unique small tubular type construction permits their installation in practically any type or make of photographic recording oscillographs. These galvanometers are offered at low cost over a wide range of frequencies and sensitivities to satisfy most recording requirements. For additional information, write for our Catalog No. CGC 206.

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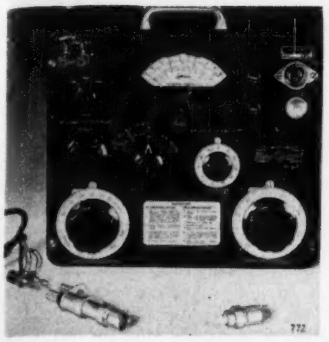
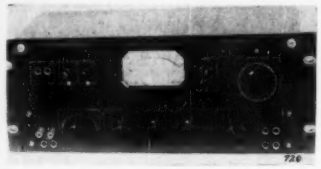


power range is 0-500 milliwatts. Instrument operates from 60 cps. line. Measurements are made either by a direct-reading or substitution method.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

Mention No. 1330 when filling out card.

Transmission Measuring Set

New "Type BI-11A" transmission measuring set consists of a volume indicator, input and output attenuators, impedance matching system, and jacks for connection. A multiplier, geared to load-impedance shaft, provides automatic correction for changes in load



impedance. Switches facilitate connection of volume indicator to input of attenuator system, or to jacks for external connection. An output impedance switch allows matching to 600, 250, 150, 16, 8, or 4-ohm circuits. Instrument handles a wide range of load levels with an accuracy of 0.1 db from 20 to 20,000 cps.—*Broadcast Equipment Section, RCA Engineering Products Dep't., Camden 2, N. J.*

Mention No. 1331 when filling out card.

Frequency Standard

New "Type 2005" frequency standard has an output of 60 cps. accurate to 1 part in 100,000, over temperature range from 0-60 C. Input is 115 v., 50 to 400 cps., 45 watts; output is 10 watts at 115 v. Source of accuracy is a 240-

Elapsed time intervals can be measured down to 1/1000th second with a

STANDARD PRECISION TIMER

The world's most accurate (and rugged) time measuring instrument. Available in 8 models as shown below:

MODEL	READS	TOTALIZES	ACCURACY
S-100	1/5 sec.	6000 sec.	± .1 sec.
S-60	1/5 sec.	60 min.	± .1 sec.
SM-60	1/100 min.	60 min.	± .002 min.
S-10	1/10 sec.	1000 sec.	± .02 sec.
S-6	1/1000 min.	10 min.	± .0002 min.
S-1	1/100 sec.	60 sec.	± .01 sec.
MST	1/1000 sec.	.360 sec.	± .001 sec.
MST-500	1/1000 sec.	30 sec.	± .002 sec.

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✓ FEATURES

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- ✓ Ripple voltage less than 10 millivolts.
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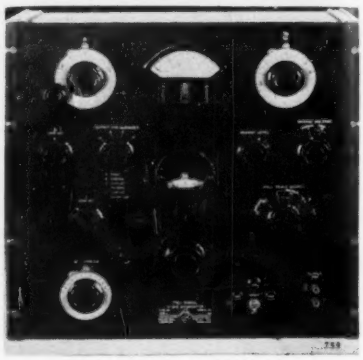
cps. tuning fork. Over-all dimensions 8x7x8 in., weight 14 lbs.—*American Time Products, Inc.*, 580 *Fifth Ave., New York* 19, *N. Y.*

Mention No. 1332 when filling out card.

Two-signal Audio Generator

New "Type 1303-A" generator will supply: (1) a single sinoidal voltage adjustable from 20 cps. to 40 kc.; or (2) two sinoidal voltages adjustable to

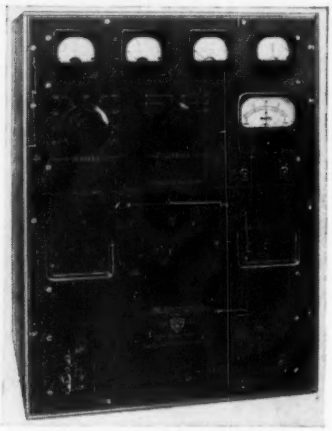


10 kc. and 20 kc., or (3) two sinoidal voltages with a fixed frequency difference as one frequency is varied. Oscillator output is adjustable up to 1 watt with less than 0.5 percent distortion, maker states. Instrument operates on 115-230 v., 50-60 cps.—*General Radio Co.*, 275 *Massachusetts Ave., Cambridge* 39, *Mass.*

Mention No. 1333 when filling out card.

Precision Phasemeter

New "Model P-1060" phasemeter operates in audio range of 30 to 20,000 cps. Phase difference is read in terms of calibrated shift required to establish



coincidence of voltages in measuring circuit. Phase angle is read from two dial settings and an indication; lag or lead can be determined. Instrument operates from 105-125 v, 60 cps. power supply; shielded cabinet measures 19.5x16x25 in., weighs 110 lbs.—*W. L. Maxson Corp.*, 460 *W. 34th St., New York* 1, *N. Y.*

Mention No. 1334 when filling out card.

D-c. Microvoltmeter

New "MV-15A" has a full-scale sensitivity of 10 microvolts, with an input impedance of 1000 ohms on 3 lowest ranges, up to 10 megohms on higher ranges; reads to 1 v. on 11 ranges.

D-c. input voltage charges a capacitor, which is discharged through a pair of contacts. Resulting oscillatory pulse is amplified, rectified, and indicated. Over-all accuracy ranges from 3 to 5 percent. Calibration can be checked and adjusted.—*Millivac Instrument Corp., P. O. Box 3027, New Haven, Conn.*

Mention No. 1335 when filling out card.

Hearing-aid-battery Tester

New "No. 12" is a pocket-size voltmeter, with ranges of 30-0-30, and 2-0-

2 v.d.c. High range has 2-v. divisions, low range 0.1-v. divisions.—*Sterling Mfg. Co., 9205 Detroit Ave., Cleveland, Ohio.*

Mention No. 1336 when filling out card.

Tube Tester Kit

New "Model 625-CK" is designed for testing all types of electron tubes. Separate switches are provided for testing

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No. 41065-B?

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This Tenney variable temperature chamber was designed and built to run environmental tests for high and low temperature (Group 10 & 20), on electronic equipment components, in accordance with 41065-B. Specified range from −103°F. to +200°F. Sizes from 3 cu. ft. to walk-in rooms.

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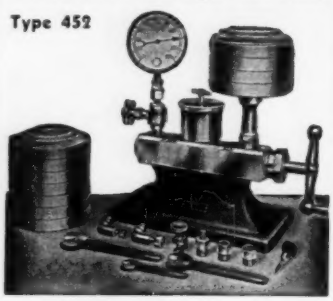

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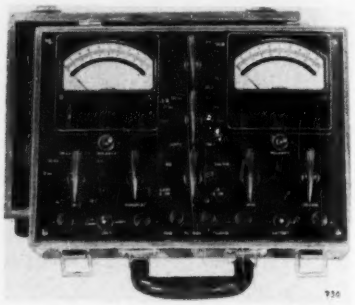
each tube element. Instrument measures 7x14x16 in.—*Electronic Instrument Co., Inc., 276 Newport St., Brooklyn 12, N. Y.*

Mention No. 1337 when filling out card.

Multi-purpose Electrolysis and Corrosion Tester

New "Model B-3" multi-combination instrument measures voltage from 2 mv. to 100 v., with low and high resistance voltmeters and poteniometer;

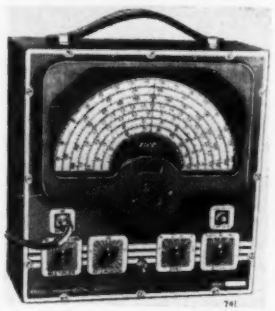


current from 2 ma. to 20 amp. Circuits for measuring lead resistance and soil resistivity are provided. Accuracy is 1 percent. Internal batteries furnish power supply.—*M. C. Miller, 1142 Emerson Ave., West Englewood, N. J.*

Mention No. 1338 when filling out card.

Signal Generator

New "Model 315-K" is maker's r-f. signal generator in kit form. Unit covers range from 75 kc. to 150 Mc. in seven steps with 1 percent accuracy.



A 400-cps. sine wave is generated for r-f. modulation and external audio testing. Power supply is regulated.—*Electronic Instrument Co., Inc., 276 Newport St., Brooklyn 12, N. Y.*

Mention No. 1339 when filling out card.

Intermodulation Meter

New "Model 31" consists of a test signal generator and an analyzer. A built-in supply provides power for both units. Generator section produces two sinoidal voltages, one low frequency and one high frequency, which are mixed in a 4/1 voltage ratio and applied to apparatus under test. Signal from equipment being tested is received by analyzer section to be filtered, amplified, demodulated and measured. Indicator is direct-reading in percent-

ages of intermodulation and input volts. Over-all dimensions 8 x 19 x 9 in.—*Measurements Corp., Boonton, N. J.*

Mention No. 1340 when filling out card.

Prospector's Geiger Counter

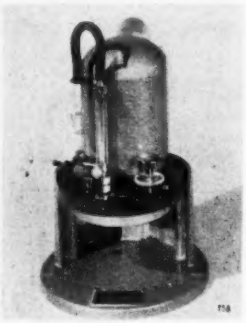
New "Super-Sniffer" is improved model of maker's prospector's Geiger counter. Counts are indicated on a flashing neon light, in addition to ear-

phones. Instrument is also sensitive to beta and gamma radiation. Flashlight batteries supply power.—*Nuclear Instrument and Chemical Corp., 223 W. Erie St., Chicago 10, Ill.*

Mention No. 1341 when filling out card.

Low-background Windowless Radioactivity Counter

New "Type SC-16" windowless flow counter operates in either Geiger or proportional regions. Background is 16



to 18 counts per minute. Solid samples are inserted in shielded counter tubes; constant gas flow prevents air contamination. Preflush chamber is built-in.—*Tracerlab, Inc., 130 High St., Boston 10, Mass.*

Mention No. 1342 when filling out card.

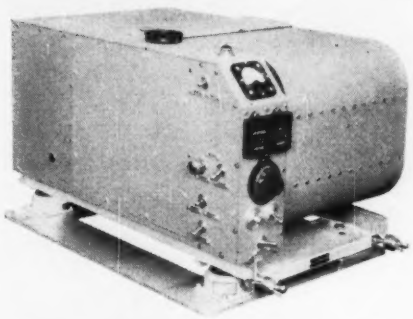
Decade Scaler

New "Mark 13 Model 10" decade scaler has input capacity less than 10 uuf; resolving time less than 5 microseconds. Voltage supply is continuously variable from 500 to 2000 v.; low voltage supply is regulated. Discriminator control is adjustable from

Century INDUSTRIAL

RECORDING OSCILLOGRAPH

FOR VIBRATION, TEMPERATURE, STRESS, STRAIN ANALYSIS



MODEL 408 OSCILLOGRAPH

The Century Model 408 recording oscillograph was designed expressly for airborne and mobile operation. As with all Century products, this oscillograph incorporates the utmost in design and workmanship, along with improved features, yet it remains simple in its operation and maintenance.

FEATURES:

Size: 29" long, 12½" wide, 8⅞" high.

Weight: 51 pounds.

Number of Recording Channels: 6 to 50.

Detachable daylight loading magazine accommodating a roll of paper or film 8" x 200'.

Friction roller type paper drive by governor controlled electric motor with separate motor for takeup drive.

Paper speeds continuously and instantly variable without changing gears or sprockets.

Separate optical system for viewing before or during recording.

Glow tube timing system photographing .01 second and .1 second lines. .01 second lines instantly removable by toggle switch for slower speeds.

Data numbering at beginning of record.

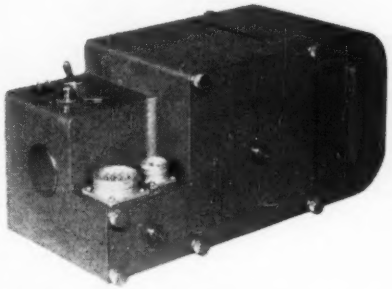
Footage indicator showing amount of paper remaining in magazine.

Automatic record length control.

Trace identification.

Remote control unit.

MODEL 409 OSCILLOGRAPH



The Century Model 409 oscillograph has been designed for recording data where space and weight requirements are limited. This oscillograph has been tested to record faithfully while subjected to accelerations up to 20 G's.

FEATURES:

Size: 5" x 5" x 11".

Weight: 11 pounds.

Cast Aluminum case.

Paper speeds variable ½" to 12" per second.

Detachable daylight loading magazine with a capacity of 3⅝" x 50' paper or film.

2 to 12 individual channels.

Trace identification.

Trace viewing.

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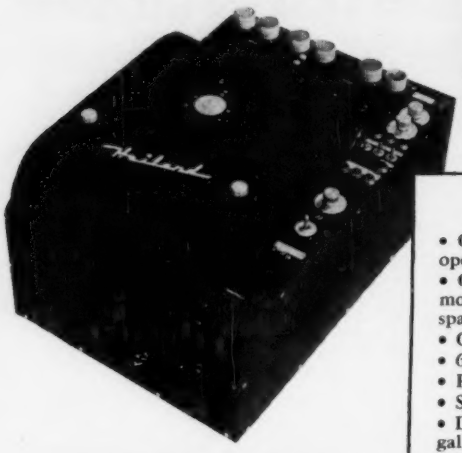

Type A-708...24-channel

AUTOMATIC OSCILLOGRAPH RECORDER

Affording complete accessibility from operating surface and requiring only a minimum of space for mounting, the HEILAND A-708 meets the exacting specifications of research and development personnel in aircraft flight testing, laboratory and industrial testing.

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FEATURES

- Completely accessible from operating surface
- Compact...can be mounted in a minimum of space...lightweight
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- Paper widths 5", 8", 12", 18"
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- Flexibility of operation
- Simultaneous viewing, recording and scanning
- Trace identification...zero mirror...synchronizing reference trace
- Adjustable automatic record length

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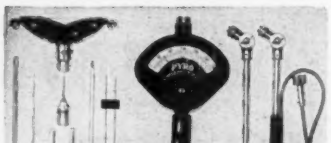

The **NEW PYRO** Surface Pyrometer handles all surface temperature measuring jobs. Has 8 types of thermocouples; all interchangeable in seconds with no recalibration or adjustment. Automatic cold end compensator, shock, moisture, and dustproof. Accurate, big 4¾" indicator. Available in 5 temperature ranges. Get FREE Catalogue #165.

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The **PYRO** Immersion Pyrometer is shock, moisture, and dustproof, immune to magnetic influences. Shielded steel housing. Instantly interchangeable bare metal and protected type thermocouples without adjustment or recalibration. Large 4" scale. Equipped with exclusive **Lock Swivel.** Get Free Catalog #150.

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PYRO Optical, Radiation, Immersion and Surface Pyrometers for over 25 years.

0.25 to 5 v. Panel switch selects scales of 10, 100, or 1000; oscilloscope connection is provided on panel. Overall dimensions 21.5x15x10.5 in.—*Radiation Counter Laboratories, Inc.*, 1844 *W. 21st St., Chicago 8, Ill.*

Mention No. 1343 when filling out card.

Radiation Counter with Preflush Chamber

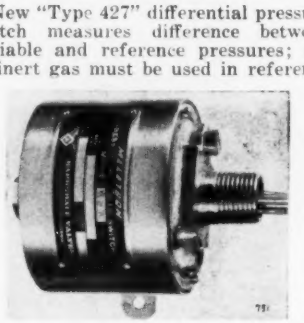
New "Mark 12 Model 2" counter has one sample chamber which is flushed while another is being counted. Unit

operates with counting gases; Geiger plateau is 200 v., and proportional plateau is 300 v. Unshielded background is less than 20 counts per minute.—*Radiation Counter Laboratories, Inc.*, 1844 *W. 21st St., Chicago 8, Ill.*

Mention No. 1344 when filling out card.

Differential Pressure Switch

New "Type 427" differential pressure switch measures difference between variable and reference pressures; air or inert gas must be used in reference

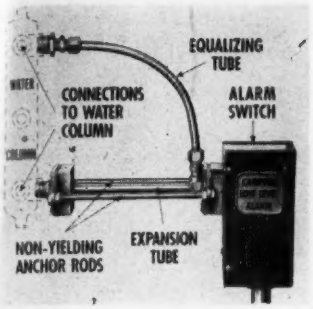


chamber. Adjustable ranges from 3 in. water to 80 psi. are available. Pressure-sensing diaphragm actuates a s-p.d-t. snap-action switch, rated for a.c. and d.c. circuits. Dimensions 3 in. diameter and 4 in. high; pressure connections 0.125 in. NPT.—*Barksdale Valves*, 4905 *Santa Fe Ave., Los Angeles* 58, *Calif.*

Mention No. 1345 when filling out card.

Low-level Boiler Alarm

New "Micro-Thermal" low-level boiler alarm consists of an expansion tube connected to water column on boiler,

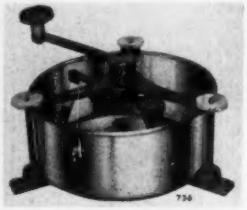


When water reaches low level, increased temperature expands tube which actuates a d-p.s-t. microswitch. A screw adjustment permits setting for operation at desired level.—*J. A. Campbell Co.*, 645 *E. Wardlow Rd., Long Beach* 7, *Calif.*

Mention No. 1346 when filling out card.

Utility Mixer

New "Utility Mixer" is hand operated and has a stainless steel mixing bowl 12 in. diameter and 5.5 in. high. Mixing unit consists of a revolving

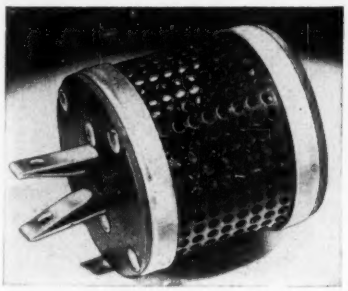


arm with a scraper for removing material from bowl wall, and a paddle that rotates on its own axis as it travels around bowl. Mixing unit is removable from bowl for cleaning.—*Claud S. Gordon Co.*, 3000 *S. Wallace St., Chicago* 16, *Ill.*

Mention No. 1347 when filling out card.

Line-voltage Regulator

New "Types TV-A and TV-B" line voltage regulators connect between out-



let and load. Models are rated 300 and 375 watts.—*Clarostat Mfg. Co., Inc., Dover N. H.*

Mention No. 1348 when filling out card.

Electric Drying Oven

New electric drying oven features back blowout panel to release internal pressure surges. Oven has temperature and limit controllers, high veloeity

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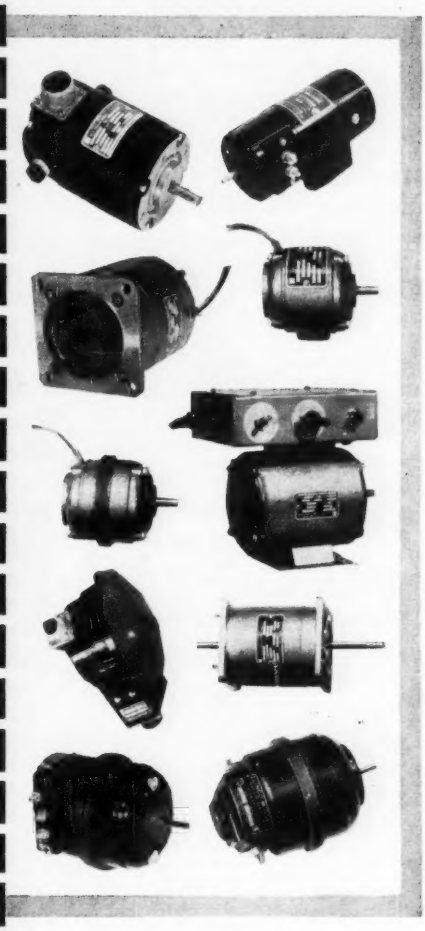

If you have a specific problem write for literature, or submit blueprints and complete details for our recommendations and quotation.

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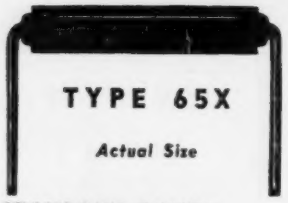

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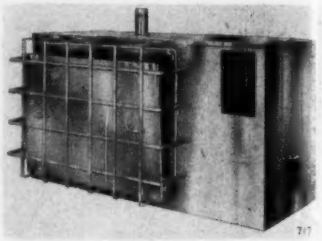
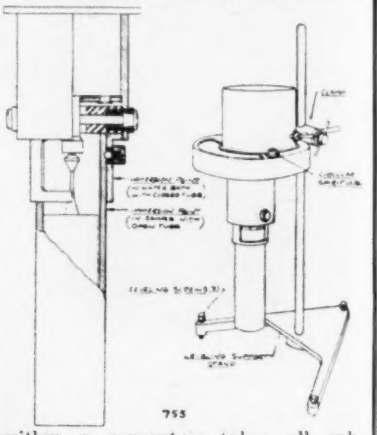


circulating air; heaters operate at low surface temperature. Sizes range from 2 to 20 cubic ft.—*Electric Hotpack Co., 5029 Cottman St., Philadelphia, Penna.*

Mention No. 1349 when filling out card.

Viscometer Adapter

New "UL Adapter" extends range of maker's viscometer to 0-10 centipoises; consists of a cylindrical spindle mounted



within a concentric tube; all submersible parts are stainless steel.—*Brookfield Engineering Laboratories, Inc., Stoughton, Mass.*

Mention No. 1350 when filling out card.

Bunsen Burner

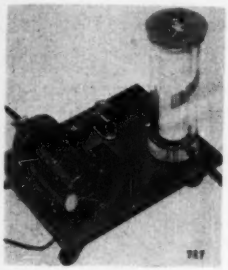
New "Touch-O-Matic" Bunsen burner produces a full flame as hand or finger touches on-off platform. As hand

is removed, flame goes out, leaving a low burning pilot. For a continuous flame, platform is depressed and turned slightly.—*Hanau Engineering Co., Inc., 1233 Main St., Buffalo 9, N. Y.*

Mention No. 1351 when filling out card.

Filter Pump

New "Model LSI-10" filter pump is equipped with a Lucite filter cylinder and a stainless steel pump; is rated 100

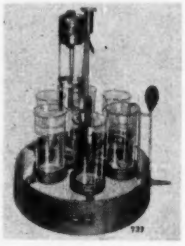


gph. Filter element is processed cotton yarn wound on a stainless steel core. Solutions up to 200 F. can be filtered.—*Sethco*, 105-07 150*th St.*, *Jamaica* 4, *N. Y.*

Mention No. 1352 when filling out card.

Sand Washer

New sand washer removes clay from sand grains by centrifugal action. A single-blade impeller driven at high speed by an electric motor throws sand grains against baffles suspended in



beaker containing sand and water. Motor is attached to a rod which slides vertically in column. A syphon with inlet exactly 1 in. from bottom of beaker removes wash water. A six-unit washer is illustrated; one unit washer also available.—*Claud S. Gordon Co.*, 3000 *S. Wallace St.*, *Chicago* 16, *Ill.*

Mention No. 1353 when filling out card.

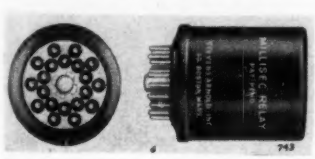
Impact Tool for Bolts, Screws, etc.

New "Impakdriver" transforms hammer blow into torque. Designed particularly for nuts, bolts, and screws hard to start and remove.—*H. K. Porter, Inc.*, *Somerville, Mass.*

Mention No. 1354 when filling out card.

Hermetically-sealed Relays

New models of "Millisec" relays come in hermetically-sealed cases, in s-p.d-t. and d-p.d-t. types. Containers are 1 x 2.375 in., with 8-pin octal bases.



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RF RANGE: 175-250 megacycles, accurate to ± 0.5%. Main frequency dial also calibrated in 24 equal divisions for use with vernier frequency dial.

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AMPLITUDE MODULATION: Utilizing the internal audio oscillator amplitude modulation may be obtained over the range of 0-50%, with meter calibration points at 30% and 50%. By means of an external audio oscillator the RF carrier may be amplitude modulated to substantially 100%.

RF OUTPUT VOLTAGE: The RF output voltage is continuously variable from 0.1 microvolt to 0.2 volt at the terminals of the output cable; Output impedance at front panel jack is 53 ohms resistive.

DISTORTION: The overall FM distortion at 75 kc deviation is less than 2% and at 240 kc. less than 10%. The AM distortion at 50% is less than 6.5%.

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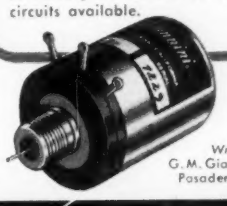

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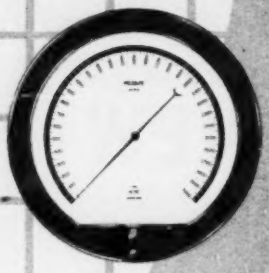
dial scale is always concentric with the pointer travel



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The scales of Heise Bourdon tube pressure gauges are absolutely concentric with the pointer rotation. Errors due to misalignment in mounting or cutting the scales are avoided since the scales are cut from their centers, and are mounted at the centers on a hollow spindle through which the pointer rotates.

Three sizes: 8½ in., 12 in., and 16 in., in ranges from 0-15 to 0-10,000 psi. Prices from $151.60 to $211.20. Write for catalog.

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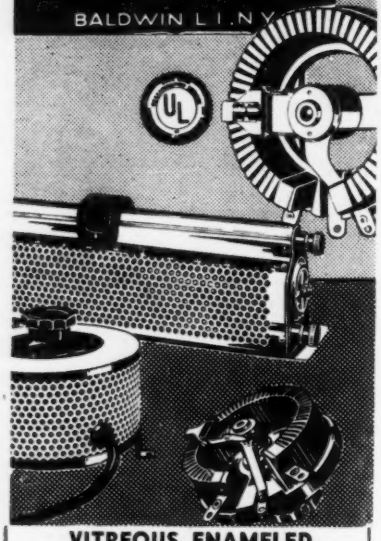

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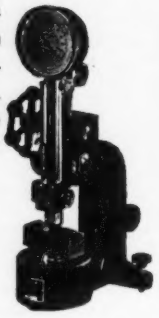

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Jamaica 2, N. Y.

Contacts are rated to 0.5 amp. at 110 v.d.c.; coils operate on 6 or 18 v. d.c. —*Stevens-Arnold, Inc.*, 22 *Elkins St., South Boston, Mass.*

Mention No. 1355 when filling out card.

Multiplier Phototube

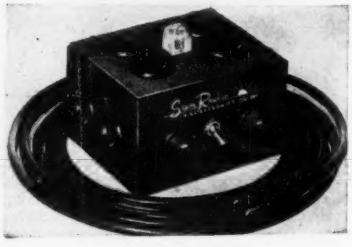
New "5819" head-on multiplier phototube is improved model with high sensitivity to blue-rich light; flat cathode

area permits good optical coupling between cathode and phosphor, maker states. Cathode lead terminates in a base pin.—*Tube Dep't, Radio Corp. of America, Harrison, N. J.*

Mention No. 1356 when filling out card.

Multiple Outlet Box

New outlet box provides for eight Edison line cord plugs. A d-p.s-t. switch turns off both legs of all receptacles; a neon pilot light indicates power on. Two

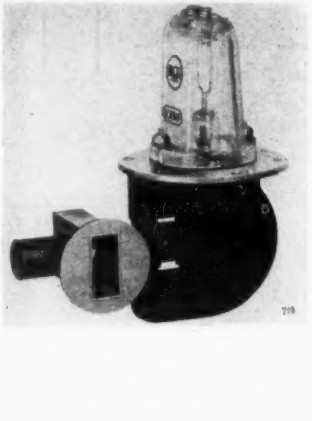


fuses and 12 ft. of rubber covered cord are provided.—*Sun Radio & Electronics Co.*, 122-124 *Duane St., New York, N. Y.*

Mention No. 1357 when filling out card.

Magnetron

New "2J50" magnetron is of internal-resonant circuit type, at a fixed frequency of 8825 Mc. Maximum peak input power is 260 kw.; at peak anode voltage of 12,000 v., peak output power



is 45 kw. at 0.001 duty factor. Output circuit consists of a loop joined to a coaxial line feeding into a matched junction to a wave-guide terminated in a standard coupler. Mounting flanges permit use where a pressure seal is required.—*Tube Dep't, Radio Corp. of America, Harrison, N. J.*

Mention No. 1358 when filling out card.

High-voltage Disconnect

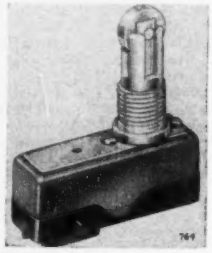
New "8101M-F" disconnect is molded from polyethylene. Operates up to 15

kv. d.c. Contact is made in last 0.25 in.; sleeve and stud form moisture seal when mated.—*Alden Products Inc., 117 North Main, Brockton, Mass.*

Mention No. 1359 when filling out card.

Roller-plunger-operation Precision Switch

New "Type MXR Adaptaplate" can absorb overtravel up to 0.218 in. Stain-



less steel roller contacts operating cam. Unit mounts on maker's basic "Unimax" switches.—*Unimax Switch Div., W. L. Maxson Corp., 460 W. 34th St., New York 1, N. Y.*

Mention No. 1360 when filling out card.

Photoelectric Relay

New "Model PB-1" photoelectric relay is mounted in weatherproof cases. Light unit is equipped with trans-

former, light source and lens; pickup contains photocell and s-p.d-t. relay rated 3 amp., non-inductive load.—*Experimental Engineering Corp., 96 S. Washington Ave., Bergenfield, N. J.*

Mention No. 1361 when filling out card.

Instrument Gearbox

New "Hi-Reduction" gear box provides ratios from 20:1 to 3125:1. Shafts and pinions are stainless steel; gears and housing are aluminum alloy. Gears and class 7 precision ball bearings have special lubrication. Unit is 3.5 x 3.5 x 2.25 in., weighs 24 oz.—*Link Aviation, Inc., Binghamton, N. Y.*

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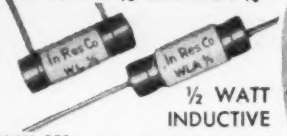

½ WATT INDUCTIVE

MAX. RES: .01 to 7,500 ohm (331 Alloy) .01 to 4,000 ohm (Nichrome) .01 to 1,250 ohm (Manganin)

BODY SIZE: 5/8" lg. by 3/16" diam.

TOLERANCE: STANDARD 1%

TYPES WL and WLA

1 WATT INDUCTIVE

MAX. RES: .01 to 15,000 ohm (331 Alloy) .01 to 8,000 ohm (Nichrome) .01 to 2,500 ohm (Manganin)

BODY SIZE: 1" lg. by 3/16" diam.

TOLERANCE: STANDARD 1%

Can be supplied non-inductive with one-half indicated maximum resistance.

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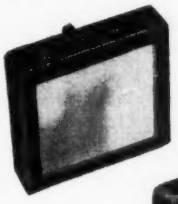
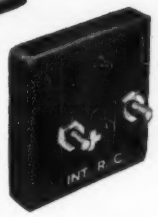


Front View Type DP-5.



Rear View Type DP-5.

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BRITISH ELECTRONICS SYMPOSIUM

Continued from page 1133

erated across the secondary winding of the associated transformer for known radiation levels at different interruption frequencies and at a prescribed wave-form. The equipment shown is a first step in making tests of this kind.

"User vs. Maker" Discussion Session

The Exhibition provides a most attractive platform for discussions between manufacturers and their customers. This is not uncommon in discussions on exhibition stands, but a new feature was incorporated in the 1950 Symposium in that one session was given over to papers and discussion by instrument users who commented on their instrument requirements and how these were being met by manufacturers. This proved a most attractive feature and an amusing and stimulating discussion followed. Such exchange of ideas must be of great use to both instrument manufacturers and users alike.

TECHNICAL SOCIETIES

SOCIETY FOR APPLIED SPECTROSCOPY

The December meeting of the Society for Applied Spectroscopy will be held on Tuesday the 5th: 6:00 p.m. Informal dinner, Tosca's, 118 Fulton St., New York, no reservation necessary. 8:00 p.m., Regular meeting, Socony-Vacuum Training Center, 63 Park Row. Speaker, Dr. R. F. Stamm, American Cyanamid Co. Subject, Raman Spectroscopy and Photoelectric Raman Spectrometer. Technical Chairman, Dr. David N. Kendall, American Cyanamid Co.

Charles H. North,
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South Amboy, N. J.

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1. The names and addresses of the publisher, editor, managing editor, and business manager are:

Publisher, Richard Rimbach, Pittsburgh, Pa.; Editor, M. F. Behar, Pittsburgh, Pa.; Managing Editor, Richard Rimbach, Pittsburgh, Pa.; Business Manager, Richard Rimbach, Pittsburgh, Pa.

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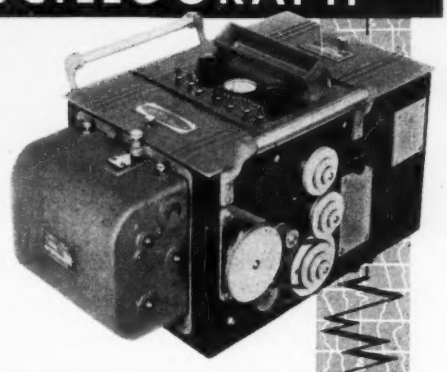

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Continued from page 1136

tion of diaphragm expansion and hence is indicative of gas pressure.

This mutual inductance is compared to an adjustable reference value which is set in calibration for equality with zero differential in the cell. When pressure is applied, the balance is disturbed, and the resulting signal is proportional to gas pressure. This signal is amplified by suitable circuitry, is rectified, and finally appears as a direct current through the microammeter on the panel of the instrument.

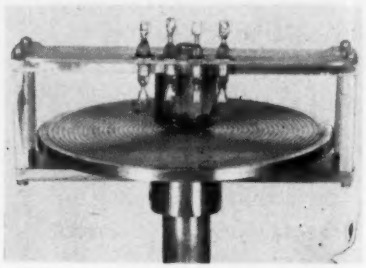

Fig. 3. Heart of the micromanometer is the pressure cell, which is composed of a thin corrugated diaphragm sealed to a slightly dished brass disk.

Alignment of coil form and diaphragm is not critical since, as a result of the linear response, all parts of the useful area of the diaphragm are weighted uniformly.

Because of the linear relationship between pressure variation and electrical output, only two calibration points are required. In practice, the cell is first evacuated to the same pressure as that prevailing in the glass dome. Thus no differential pressure on

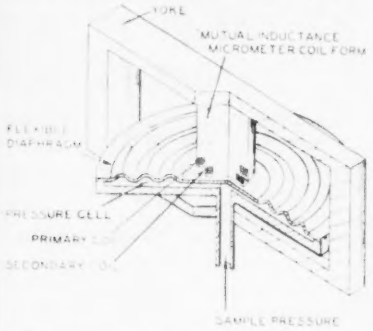

Fig. 4. Cut-away diagram of pressure cell illustrated in Fig. 3.

the diaphragm exists, and the reference mutual inductance may be adjusted for zero reading on the meter scale. Slope, or scale-factor, adjustment is then made upon the introduction of an expanded gas sample of known pressure.

The manometer is capable of measuring pressures in the range of 1 to 100 microns with a sensitivity of about 0.1 micron on a 50-micron scale. Continuous use of the instrument for more than one year on one of the mass spectrometers at the NBS has shown that its sensitivity and zero point are remarkably constant. Frequent observations have disclosed variations in calibration of less than 1 micron over a 24-hour period. A differential pressure of one atmosphere applied externally on the

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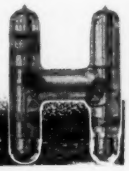

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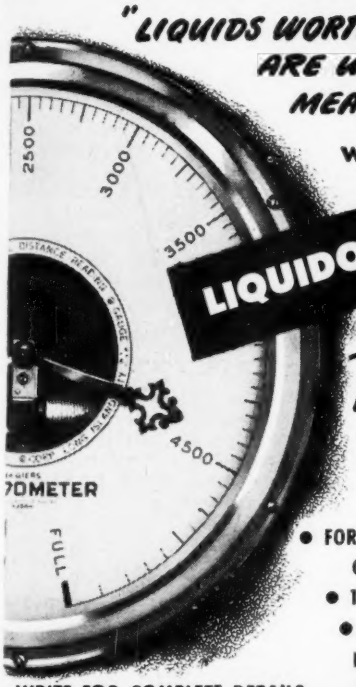

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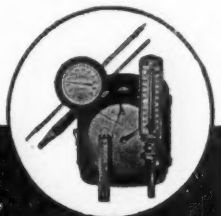

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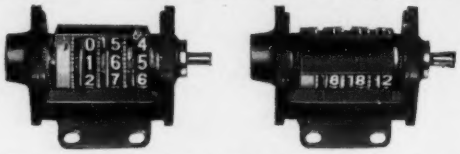
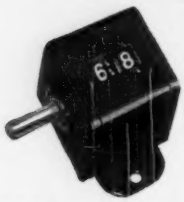
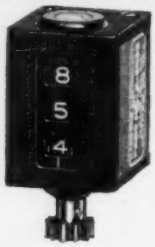


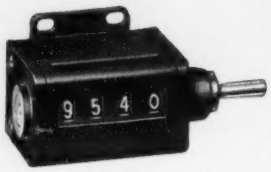
Companion shutter counters used as dual direction indicators. One counter adds while the other subtracts. Shutter blanks out counter which is on negative side of 000.



"Y" 2-figure Rotary Counter used in navigating instruments.



High-speed, non-reset "Y" type counter for building into radar instruments.



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Rain-makers Get Loan of Weather Instruments

BALTIMORE, Md.—Scientific weather recording instruments to equip four meteorological stations are being loaned to directors of New York's artificial rain-making project by the Friez Instrument Division of Bendix Aviation Corporation. The rain-making experiments may be of tremendous importance to many industrial fields and agriculture, as well as the fortunes of cities. They involve the seeding of clouds with dry ice and the use of silver-iodide smoke for inducing precipitation.

LeRoy D. Kiley, general manager of Friez Division, said the instruments were being made available to the city as a public service and in the interest of meteorological progress.

Included among the instruments are standard aerovane wind speed and direction equipment, maximum and minimum thermometers, hygrothermographs and microbarographs. In addition, two unusual instruments will be especially developed by the company at the request of Dr. Wallace E. Howell, Harvard University meteorologist who is directing the experiments. One of these, a nephoscope, will measure the movement and apparent speed of clouds. It will help determine when clouds are heading over the watershed and how long it will take them to get there. The other instrument, an illuminometer, will measure the amount of visible light coming from the sky and disclose the density of clouds by the amount of light passing through them.

Dr. Howell estimates it will be six months before enough statistics are available by which to measure the success of the rain-making experiments.

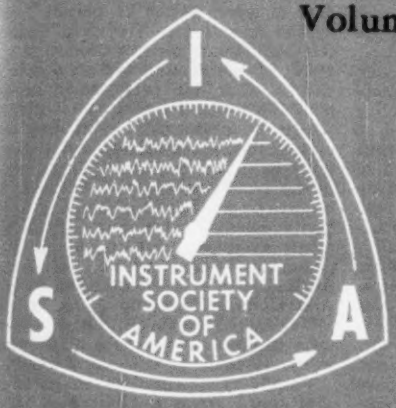
100-Mev. Betatron at Chicago U.

CHICAGO.—The largest and most powerful commercially-available particle accelerator, a 100,000,000 electron volt General Electric betatron, is now installed and being tested at the University of Chicago, according to the company's Special Products Division.

First complete unit of its type ever sold by G. E., the new giant will be used for nuclear research by the staff of the University's Institute for Nuclear Studies which includes Dr. Enrico Fermi who is well known for his work in atomic development.

Engineered by the G-E General Engineering and Consulting Laboratory, the betatron includes a 160-ton magnet, a 24,000-kva. capacitor bank, power and electronic cubicles, and a control console.

Volume 6 November 1950 Number 11



Journal

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Remarks of President-Elect J. B. McMahon

WHEN the agenda for the Board of Directors' meeting was being formed, I asked that a few minutes be allotted to the newly elected President. It seems to me that this is fitting, since he will have the responsibility for the Society's operation during the coming year, and it has been my observation that smoother operation of the Society and fewer misunderstandings might readily result from a statement to the Directors by the new President of what he conceived were the main problems confronting us.

As I see it there are three main problems, and the Directors can help immensely on all of them.

First, morale. By this I mean the maintenance of enthusiasm and interest among the members. Very largely this is achieved by successful operation of the local sections. The average member does not get to attend the National Conference and Exhibit every year, and therefore practically his sole contact with the Society comes through his local section. The officers of his section must provide him with technical programs of a stimulating nature to maintain his interest. That is the first consideration, and a great deal of thought and work and planning should be devoted to it.

But that does not necessarily convince him that the National Society is doing anything for him, and that is where you—the Directors—come in. I feel that it is largely up to you to acquaint the member with where his dues money goes. Certainly at this meeting here, you can pick up enough information for the substance of several 15-minute talks to your sections. Ask your program committee for the time for them.

If you have a dinner meeting, a 15-minute talk right after dinner would work in very nicely. If no dinner is held, 10 or 15 minutes before the technical address of the evening would not be amiss. Make a general report on the convention and exhibit at the first meeting after you get back. Then, at later meetings, prepare and give individual talks on separate phases of the Society and its operation. Keep the section members reminded of the National throughout your whole program year.

The National office and officers will be very glad to help in any way they can. One comment that has been made frequently to me in the past has been that local section members never got to see their National officers. This is true to some extent, although Mr. Pigott has responded to every invitation he has received, but National officers do not visit local sections except upon request. If requested, it is my purpose to attempt to visit as many Sections as is physically possible during the coming year; but in order to do so, I will have to have a lot of help from the sections themselves.

Naturally, I cannot run over to Boston one week, New York the next, Philadelphia the next, and so on. Even aside from the time, the expense would be prohibitive; and, as you know, such trips are not financed in any respect by the Society. My company is perfectly willing to finance such trips, provided they are kept within reasonable bounds, which means that visits to several sections must be arranged for each trip. Therefore, neighboring sections must get together and plan their programs to accommodate, if they desire such visits.

Mr. Rimbach has already written the sections about this and, if it seems desirable to you, we urge you to take vigorous and immediate action on it, since we are already into the program season for this year. May I suggest also, that where such visits are arranged, I will be very glad to meet with Section Executive Committees before the section meetings, to discuss problems confronting them, and such National questions as they are interested in.

The second big question before us is the matter of finance and operation. We are slowly acquiring a financial backlog which will assure us of the stability necessary to permit us to devote somewhat more of our income to projects which have had to be deferred until we had an adequate surplus. All of us need to devote considerable thought to this. It would not be at all difficult for the Society to dissipate its energies and finances in projects which, while desirable, are beyond our means.

You have had the report of the Publications Committee, which illustrates an example. Ever since the formation of the Society we have been attempting to work out some means to relieve Mr. Rimbach of the financial sacrifice he has made, and makes, as Secretary. To date this has not proved feasible, but it must be done before too long. This question has been referred to the Committee on Society Structure and Planning, and it is hoped that before long, that Committee will be able to evolve a practical answer to this problem.

The proposed amended Constitution and By-Laws are the result of our experience to date with Society operation, and should aid considerably in the definite determination of duties and powers. In addition to this, however, we need a code of rules and procedures. A very good codification of previous acts and rulings of the Society was made by Mr. C. C. Vogt of the Washington Section two years ago, but it has not been kept up to date, nor correlated to make it useful. Such a code has been worked out by the Chicago Section for its own operation, and copies have been sent to all sections.

We badly need a similar job done for the National Society. This belongs under the work of the Committee on Rules and Procedures, which is now a sub-committee of the Constitution Committee. Mr. Pigott has agreed to serve this coming year as chairman of the Constitution Committee, and has promised that he will (forcibly if necessary) get a sub-committee actively at work on this project.

This is a very good example of a lot of jobs that need to be done by Committees and sub-committees. A great deal of it is hard, grinding, uninteresting work, which would never be done by anyone, except for pay or because he has a real interest in making our Society a success. But such work is vital to the Society, and I sincerely hope that when you are asked to serve on a Committee confronted with such a task, you will agree to serve, and will see to it that the work gets done. In some cases, we—the Executive Committee—may appeal to you for help in checking up on such work, and I hope you will help us when asked. We have asked for names of Society members to serve on Committees, and it should be noted that we need these names promptly—they do not help if not received until the operating year is half gone.

The third thing that I feel is vital to success of the Society is the success of our annual Conference and Exhibit, as such. The Exhibit speaks for itself. It has established itself as the prime source of information on equipment developments, and is undoubtedly here to stay. We can take real pride in it, and credit is due to Mr. Rimbach in his capacity as Exhibit Manager, for the statement made repeatedly by exhibitors, that ours is the best run of all.

However, the standing of the Society in the industrial world is determined, not by the Exhibit, but by the quality and volume of the papers presented at our Convention. It is through these that our ability in our field is presented to the world at large, and it is therefore vital that our programs present papers of the highest quality possible, in sufficient number to testify to the vitality and importance of our field of work. We can be justly proud of our accomplishments to date in that respect. But we cannot stand still. We must continue unremittingly in the search for authors and papers who have new and convincing stories to tell, and that is a year-round task, in which our Technical Division, which is responsible for securing and handling papers, needs your help.

Somehow, an impression seems to have formed that papers are submitted to the Society upon invitation only. That is far from being the case. We welcome papers pertinent to our field from any source, within or without the Society. We would appreciate it if you would spread that word as widely as possible. Emphasize it to your Section members, and invite them to submit papers. Also emphasize to them, and any other prospective authors, the importance of submitting manuscripts far enough in advance of the prospective date of presentation to permit review by the appropriate Technical Committee, possible revision or rewriting as a result of the review, and final submission in time for preparation of preprints for the meeting at which the paper is presented. Point out that manuscript, illustrations, and drawings must be in the prescribed form, shown in the instructions sent to authors. And be sure to point out that writing a good paper always takes more time than seems necessary. Anyone planning on presenting a paper at next year's Conference should start work on it NOW. And all committees, and others interested, should start work now. Getting up a technical program is a full year's work—it can't be done in six months.

Finally, I should like to point out that there exists a Committee in the Society whose prime concern is the welfare of the Sections. That is the Sections and Membership Committee; and I should like to suggest that you form the acquaintance of the members of that Committee, particularly the one from your area, and that you invite *him* to one of your Sectional meetings, to meet your members and discuss the questions they have. You will find that he has had the benefit of the experiences of many other sections, as a result of his Committee work and that he can be very helpful.

Recommended Practices Committee September Meeting at Buffalo

The following is a report on the activities of the Recommended Practices Committee of the I.S.A. during their meeting in Buffalo, New York, on September 17, 1950.

This meeting was by far the most successful one that the Committee has had to date. 23 members out of a total of 25 members for the committee attended.

The committee has now assigned the following projects which are briefly summarized including the status of their work.

RP-1—Thermocouple and Thermocouple Extension Wire Standards

This committee already has published a color code and symbol system which may be used to identify the various types of thermocouple materials that are used in industry. It is proposed to publish the calibration tables for all of the thermocouple materials that are commonly used for industry. This should be available in the Spring of 1951.

RP-3—Head Type Meter Auxiliaries

This committee has recently been organized and proposes to recommend methods for fabrication of seal, condensate, sediment and vent chambers. In addition, they will recommend practices for the installation of gas and liquid purge systems.

RP-4—Control Valves and Bypass Manifold Installations

The Recommended Practices Committee, in conjunction with the National Steam Specialty Club, have developed a standard face-to-face dimension for control valves for the following ratings and sizes:

125 lb. and 250 lb. cast iron
150 lb., 300 lb., 400 lb., and 600 lb. standards in steel, sizes from 1½ in. through 8 in.

This accomplishment is highly significant in the industry, as it can be appreciated that engineering time will be saved. This committee is currently working on designs for control valve bypass manifold installations and will publish their work on this phase some time between now and the end of the year. This work will be of enormous value to industry, since it will simplify the number of fittings and valves that will be required to fabricate these installations.

RP-5—Flow Plan Symbols

This committee has published a Recommended Practice for instrument symbols to be used on engineering and instrument flow plans. It is suggested that users consider incorporating the recommendations into their engineering work.

RP-7—Pneumatic Pressure Tests

This committee has submitted a report that will shortly be ready for publication. The work covers methods of testing pneumatic control systems before being placed in operation. A standard procedure of this type should be

of enormous value to industry on the start-up of new units.

RP-8—Outside Instrument Protective Cabinets

This committee has recently been organized to develop designs of protective cabinets. The object is to develop a simple design which can be mass produced at low cost.

RP-9—Instrument Tubing

This committee is making a study of new methods for interconnecting pneumatic-operated measuring and controlling devices.

RP-11—Handling of Mercury

This committee has prepared a comprehensive report outlining the proper methods of handling mercury from the standpoint of safety and health.

RP-12—Instrumentation for Hazardous Locations

This committee has recently been organized to make a survey of industry with the object of simplifying the installation of instruments in hazardous locations.

RP-13—Instrumentation for Corrosive Services

This committee is concentrating on the methods of making piping hookups for materials that are difficult to handle.

RP-14—Primary Elements for Head Meters

This committee is preparing a report on the correct installation procedure to be followed in the installation of orifice plates, flow nozzles, Pitot tubes and Venturi tubes.

RP-15—Head Meter Installation, Calibration and Piping

This committee was recently organized, and the scope of their work is restricted to the measuring device which is connected to the primary element. Their work will emphasize some of the following:

Installation Practices
Definition of Pressure Ratings
Terminology and Calibration Units
Connection Size and Location
Weather Protection and Heating
Meter Support Arrangements, etc.

RP-16—Variable Area Meters

No appointment has been made for a chairman of this committee but attempts are being made to obtain a chairman from among the leading manufacturers or users of this type equipment. The scope of their work will be similar to RP-15.

RP-17—Survey Committee on Plant Type Analytical Sampling Systems

This committee has recently been organized and their work will cover installation and methods of obtaining samples for industrial type analyzers.

It will be noted from the above list of projects which this main committee has undertaken that they have a very ambitious program, and considering the relatively short existence of the main committee, namely four years, coupled with the fact that they have already published several Recommended Practices which will be of considerable value to industry, we can look forward to further accomplishment as time goes on.

One further point which is of interest is that the Instrument Society of America now holds an associate membership in the American Standards Association.

Individuals who are interested in participating in any of the foregoing projects or who desire to comment should address the Chairman, Mr. W. H. Fortney, c/o Humble Oil & Refining Co., P. O. Box 3950, Baytown, Texas.

—HAROLD M. MCCARTHY
Publicity, RPC, ISA

In The Vernacular

An American and an Englishman were discussing instrumentation with the American expounding on "Automatic Reset." The Englishman was lost and asked for an explanation. After hearing the explanation he popped up to say: "Oh, you mean a 'Chase me Charlie'."

Report by Committee on Society Structure and Planning

Committee: E. G. Bailey, A. E. Tarr, John J. Grebe, Charles H. Colvin, Ralph D. Webb, G. F. Akins, W. G. Brombacher, A. H. Shafer, *Chairman*.

In the President's Report to the Board of Directors, dated August 15, 1949, page 6, the following assignment was presented to the Committee.

"Study, with recommendations of general exhibit policy, taking into consideration the frequency, locations, types of exhibits, as well as administration of exhibit policy."

Report of Sub-committee I

The Instrument Society of America has a great opportunity, not only to continue the rapid progress already made, but to acquaint the process industries and others most susceptible to profit from the full use of instruments, with their continuing development and application.

This can be done by the presentation of papers and discussion on all suitable topics and through Exhibitions of Instruments and their application to uses, and especially to the process industries.

The Sub Committee has reached the following conclusions:

1. Predicated upon there being Annual Meetings of ISA, we recommend an Exhibit simultaneously with each annual meeting, providing there are good programs of technical and other appropriate papers, and that each meeting is held at a place where exhibitors will participate and users will attend to the extent necessary to make such exhibit profitable to all.

2. That an annual national meeting promotes continued interest in the Society and makes advances in the art available to a great number of interested persons over a wide geographical area.

3. Unless exhibits continue to be newsworthy, stimulating, and informative,—and unless exhibits attract all levels of personnel in industry,—and unless exhibits contribute something of value for members to take home with them for solving their technical problems, these aims may not be realized. Such a condition might be detrimental to the Society and its members.

4. There are probably enough companies in the instrument industry to warrant an exhibit on some scale at each of the annual meetings. Instruments, meters, controls, etc. can usually be exhibited and demonstrated with full sized equipment.

5. Instrument manufacturers should not feel compelled to participate annually unless it is practical and profitable to do so, nor should they feel any compulsion to take space in proportion to their prestige or volume of business.

6. Exhibitors are urged by many of the process industries representatives to reduce objectionable types of entertainment to a very minimum, or preferably, omit them entirely.

7. We recommend a Standing Committee on Meetings and Exhibits, with two Sub-committees, one on Meetings and Programs, and one on Exhibits.

8. Such aims should enable the Society to advance satisfactorily within these important fields.

R. D. Webb
A. E. Tarr
John J. Grebe
E. G. Bailey, *Chairman*

President's report to the Board of Directors, dated August 15, 1949, Page 6, the following assignments were presented to the Committee:

"Possibility of increasing Society income, in addition to assuring financial stability under conditions of reduced business activity.

"Consideration of question of Company members for the Society, either instrument manufacturers or users, or both."

Report of Sub-committee II

This Sub-Committee reports progress in its work, but is not prepared to present a complete report at this time. The preliminary report was discussed in general committee. To assure clarity these assignments are now defined as follows:

"To determine the advisability of ISA having Company memberships for Instrument Manufacturers and/or Users. Means of increasing the financial stability of the Society."

G. F. Akins
Charles H. Colvin
A. E. Tarr, *Chairman*

The President's Report to the Board of Directors, dated August 15, 1949, Page 6, the following assignment was presented to the Committee:

"Review of the entire Society Structure with regard to present standing Committees, the completeness and suitability of the definitions of duties for these Committees, as well as their allocations to the proper administrative division."

Report of Sub-committee III

This Sub-committee reports progress in its work, but is not prepared to present a complete report at this time.

Discussion in general committee and returned to the Sub-committee for further study.

Ralph D. Webb
G. F. Akins
E. G. Bailey
W. G. Brombacher, *Chairman*

Motion of Executive Committee February 10, 1950, Page 4, Article 10.

"The Committee on Society Structure and Planning consider the advisability of establishing geographical boundaries for local Sections."

Report of Sub-committee IV

It is deemed inadvisable to establish Section boundaries at this time.

In view of the rapid growth of the Society and the consequent formation of new sections, fixed boundaries would be subject to frequent revision. The initial establishment and continued revision of areas may lead to confusion regarding the jurisdiction of sections and the equitable affiliation of individuals. The present system appears to meet the aims of the Society.

John J. Grebe
Charles H. Colvin
G. F. Akins, *Chairman*

Motion of Executive Committee June 19-20, 1950, Page 2, Article 4.

"The report of the Constitution Committee be submitted to the Society Structure and Planning Committee for study and that a report to the Executive Committee be requested by August 1, 1950."

Our report to the President dated July 24, 1950 indicated it would be impossible to prepare a report to the Executive Committee by August 1, 1950 as requested.

In general committee September 7-8, 1950 the following report was unanimously approved:

It is recognized that the proposed amended Constitution represents much study and effort. Those responsible are to be commended for their work.

This Committee will use this version and feels that it will be very helpful as a guide in its study of the structure and planning of the Society.

The forthcoming recommendations of this committtee, if accepted, may require changes beyond those made in the proposed amended version. For example, one present committee assignment may call for a new type of society membership. Another assignment calls for a review of the society structure in regard to all standing committees and their duties.

To further the value of this document and to avoid expensive revisions and confusion, it is recommended that adoption be deferred until recommendations regarding major structure changes can be submitted by this Committee.

Motion of Executive Committee July 28, 1950, Page 2, Article 9 revised.

"The special report of the Meetings and Finance Committees be referred to the Society Structure and Planning Committee with a letter of transmittal by Feeley."

In general committee September 7-8, 1950, the following report was unanimously approved:

The report of Sub-committee I on General Exhibit Policy attached carries this subject as far as possible. Action on this report by the Executive Committee and/or Board of Directors will be required before further action can be taken on this question by the Committee.

Report of Technical Committees Division

By V. P. ARNOLD O. BECKMAN

One of the major responsibilities of the Technical Committees is the procurement of papers for the technical program for the National Instrument Conferences. The details of the technical program for the Fifth National Instrument Conference, to be held in Buffalo, are published in the August issue of *Instruments* and need not be duplicated here.

Forty-two papers will be presented, distributed among the various groups as follows:

15—Instrumentation for Production Processes—(D. M. Boyd, Jr., Chairman)
11—Instrumentation for Testing—(W. A. Wildhack, Chairman)
4—Inspection and Gaging—(R. L. Geer, Chairman)
3—Maintenance and Operation—(L. C. Laird, Chairman)
6—Analysis Instrumentation—(D. J. Pompeo, Chairman)
3—Transportation—(F. H. Catlin, Chairman)

A preliminary review of the papers shows that the technical program for the Buffalo meeting will be of high quality. The procurement of technical papers of merit is a difficult task and the Society is indebted to the chairmen of the committees listed above for their effective efforts in providing the ISA technical program for the Buffalo meeting.

All of the technical committees have carried on their usual organizational and functional duties. Items which may be of special interest are the following:

The *Recommended Practices Committee*, under the able chairmanship of W. H. Fortney, has continued its effective activities. The Instrumentation Flow Plan Symbols which were described at the last general meeting of the Society, have been issued as ISA Tentative Recommended Practice RP5.1. Much favorable comment and some helpful suggestions for future modifications have already been received from leading instrumentation engineers.

The committee is working in close cooperation with the American Standards Association, Anker E. Krogh serving as liaison member.

The committee has revised proposed uniform standard face-to-face dimensions of flanged control valves. The recommendations will be published soon as RP4.1.

A new development on which it is hoped action will be taken during the Buffalo meeting is a proposed sub-committee on Telemetering. It has been proposed that the Recommended Practices Committee establish a sub-committee for the purpose, among others, of establishing standard terminology and definition of terms used in telemetering. The IRE and the AIEE already have sub-committees on telemetering, and there is, in addition, the National Telemetering Forum which meets two or three times a year. The manner in which the ISA can cooperate with these groups most beneficially will be discussed at the RPC meeting on September 17, 1950.

The *Committee on Instrument Maintenance and Operation*, L. C. Laird, chairman, in cooperation with the Niagara Frontier Section Educational Committee, assumed responsibility for arranging the Maintenance Clinic which will be held on Friday, Saturday and Sunday preceding the Buffalo meeting.

The *Sub-committee on Instrument Mechanic Training*, George Larsen, chairman, received many requests for outlines, tests, etc., on instrument mechanic training from plant managers and supervisors and from instrument mechanics seeking self-improvement. A Proposed Training Outline has been prepared and is now being studied in detail. The proposal has been made that the ISA establish standards for instrument technician qualifications, but more consideration must be given to this proposal before any recommendations will be made.

My responsibilities as Vice President in Charge of Technical Committees will terminate following the Buffalo meeting so I take this opportunity to express officially my thanks and appreciation to the chairmen and members of the various technical committees for their constructive efforts during the past two years. Progress has been made in organizing and starting the activities of the technical committees in accordance with the plan which was adopted by the Society at Philadelphia two years ago. The technical interests of the Society have expanded during this period, as is demonstrated by the diversity of subject matter of the papers presented at the National Conferences. It should be clearly evident to all, however, that many fields of instrumentation are presently untouched by the Society. If the Society is to assume the role which its name implies, namely THE Instrument Society of America, then it should embrace all types of instrumentation, including industry and science in all branches. It would indeed be unfortunate if, merely because the initial motivation for the founding of the Society arose from predominately industrial instrumentation, the growth of the Society should be retarded and the Society should fail to attain its full stature from failure to place adequate emphasis upon non-industrial instrumentation. It is my hope that future vice presidents in charge of technical activities, whoever they may be, will concur in this view and will constantly endeavor to extend the Society's influence into all fields of instrumentation.

As the Society grows it will be necessary to make changes from time to time in its organizational structure. This is particularly true for the technical division. It should be recognized that the present arrangement of nine technical committees is a temporary one. As the Society's interests expand and as experience is gained in the handling of the technical activities of the Society it must be expected that new committees will be required and that the technical committee structure will need to be revised from time to time. An example of the possible need for revision is the present indefinite status of the Committee on Education. This technical committee is at present inac-

tive because of doubt as to whether educational activities should be the function of a separate committee or whether educational activities are part of the duties of each of the other technical committees. This perplexing problem has been referred to the Society's Structure and Planning Committee and it is hoped that a guiding recommendation will be forthcoming from the Committee in the near future.

A controversial issue which is beginning to develop is the nature of the Technical Program of the National Conference. One school of thought holds that the papers should be mainly invitational and should be completed and submitted several months in advance of the conference so that preprints, program details, etc., can be arranged with the minimum of confusion. Papers failing to meet this requirement would not be accepted. Another school of thought holds that ease of preparation of preprints and programming is of secondary importance and that the primary objective of the Technical Conferences is to give ISA members attending the conferences the benefit of hearing of the most recent developments in instrumentation—an objective which cannot be accomplished if deadlines are set months in advance. Some even question the advisability of preprinting because this practice tends to diminish the value of attendance at technical sessions.

The nature of the technical sessions of the Society will be a large factor in determining the growth and the future prestige of ISA in the fields of instrumentation. The Executive Committee should devote much thought to this vital matter and should, as soon as possible, establish broad policies which will end the present confusion and controversy and will unite all members in their sincere efforts to further the best interests of the Society.

Report of the Membership Relations Division

By V. P. NELSON GILDERSLEEVE

1. *Historical Committee*—
Chairman S. W. Prince

A brief history of the ISA that was completed about a year ago is being revised and enlarged slightly by Dick Rimbach, and is to be made available in an early issue of the *Journal*. The Historical Committee continues with the assignment of preparing a detailed history of the Society to cover its first five years of operation.

2. *Coordinating Committee*—
Chairman E. S. Lee

This Committee stands ready to aid any ISA Committee in contacts or liaison of any sort with other technical societies. It has had no special activities during the year to be reported.

3. *Advisory Council*

The Advisory Council has been an inactive standing committee since the start of the Society; there is no present expectation of activating it.

4. *National Defense Committee*—
Chairman R. L. Goetzenberger

There was little activity possible for this Committee until Mr. Symington's appointment as chairman of the N. S. R. B. and the real activation of this Board. At the present time there can be seen an accelerated activity in instrument job classification descriptions for use in deferments, etc.

5. *Instrument Manufacturer's Committee*—Chairman R. E. Olson

R. E. Olson has recently accepted chairmanship of this committee, whose job it is to advise the Society upon questions of policy relating to the instrument industry and on methods whereby the Society can contribute to solutions of problems of training, placement, public information, standardization, and technical research, to the mutual benefit of industry and society. Other problems referred to the Committee are the local exhibits that are springing up in many areas with fees charged to the exhibitors, regional maintenance clinics which take manpower from the instrument manufacturing companies, and slide films of the ISA exhibit similar to the one from St. Louis, for which the exhibitors were charged for participation.

6. *Employment Committee*—
Chairman C. F. Goldcamp

The Employment Committee has been very effectively run since its inception by C. F. ("Cy") Goldcamp. Very soon after last year's St. Louis meeting, the committee formulated and distributed "Procedure for Operation of the Employment Committee" to all Sections. The following are given as of Sept. 1, 1950:

Thirty of our fifty-two sections have appointed their own Employment Committee chairmen to serve on the National Employment Committee. This is a good improvement over September 1949 though still a rather poor showing after the consistent requests of Cy Goldcamp to the sections to appoint a member of the National Committee. As of the same date, there were forty-eight registered applicants in three different classes. During the previous year, eighty-two positions have been announced in the *Journal* and 346 applications have been received. The average "applications for position" index shows a steady decrease in men seeking employment. Of the eighty-two positions listed, sixteen were filled by ISA members through the Employment Service and five by non-members through the Employment Service, four by non-members through an agency other than the Employment Service. 19 prospective employers called at the office and secured 11 men through the use of the Employment Service File of applicants.

The one special activity of the Employment Committee during the past year was an endeavor to compile a master list of employers of instrument men. The response of our sections to this endeavor has been poor, but a few have made an all-out effort to cooperate, and to date the Employment Committee has a list of over three hundred names of individuals who are directly responsible for the employment of instrument men.

7. *Sections and Membership Committee*
—Chairman M. S. Jacobs

Shortly after the St. Louis meeting, a rearrangement of the Committee was completed in order to put the Canadian sections together under one committee

Open Letter to ISA Members

Dear Member:

What have you done in your local Section last year in offering Society services to your employer? Many of us owe our employers thanks in the name of the Society for considerable help. Some of them pay our way to Society meetings. Some buy Society publications. Some give us time during the day for Society activities. Some give us stenographic and secretarial help. Some even come to our meetings and give us personal backing there. What has your Section done for your own employer?

Has it appointed an employment committee chairman so that your employer, whether instrument user, instrument manufacturer, or instrument seller, has local help in securing from our National Employment Office names of eligible employees? Twenty Sections have not. Has your Section compiled a list of the key personnel in the area with direct responsibility for employing instrument men, thus allowing a new and perhaps extremely capable man entering a community to offer his services to your employer and strengthen your organization? Forty-five Sections have not.

One of these days your employer may want to select a good assistant for you. Insist on there being an employment committee man in your area who can help in this mission. Cy Goldcamp, National Employment Committee Chairman is waiting for twenty letters giving him the names of local employment committee chairmen to automatically become members of the National Committee. Cy Goldcamp is waiting for forty-five letters saying that your local Section has started to compile a list of eligible employers. He and others have worked and worked hard on employment activities. Why don't you insist on his working harder by insisting in your Section that the sixty-five letters are written to him in the next month?

Very truly yours,
INSTRUMENT SOCIETY OF AMERICA
NELSON GILDERSLEEVE, Vice President
Membership Relations Division

member. New sections chartered during the year are Wilmington, Central New York, Panhandle and Toledo. The Sections committee renders considerable service in this activity. Work has been done to help reactivate the New Orleans Section and work is very definitely needed in South Bend, North Texas and a few others.

It is hard to point to specific major achievements of this committee, aside from new sections and an increase in national membership since it is a service committee on the alert to help sections which are in trouble and sections looking for new ideas. It serves in the background, giving considerate help to Sections frequently, without being able to take special credit.

The "Manual of Conduct of the Chicago Section" was recently distributed to each Section. The work behind it and the success of the Chicago Section in operating with it should label it as a "must" for discussion in every section.

7. Program for the Year Ahead of the Membership Relations Division

Let it be emphatically stated first that neither individual sections nor the National Society are looking for increase in membership for the sake of bigness only. Where there are instrument men and instrument engineers who are not being serviced by other societies or can be serviced by the ISA to the individual's benefit, then the ISA is anxious, of course, to increase its growth and to render more service to more people.

A local Technical Committee structure has been fully tried in one section and partially tried in others to the great benefit of the section and pleasure of the members. The Sections have given good programs and many programs; Chicago had 18 last year to satisfy its membership. Most sections have not followed suit or tried to follow suit. Therefore, I propose that next year the theme of each section ought to be KNOW YOUR MEMBERS BETTER. This involves a thorough analysis of the present membership and of the potential section membership.

To those sections who claim that they are presenting programs according to the needs of their members, the formulation of the technical committee set-up in the local section and the assignment of programs to these committees will strengthen the section's faith in its own action and give greater opportunity for the individual member to participate in the field or fields in which he is most interested. Not only should the actual program material be studied, but also the level of technical presentation of each and every paper. There are many variables which can be worked out if there is adequate manpower in local technical committes. "Know Your Members Better," and be sure you give them what they really want.

Interim Report of Operating Division

From September 1949 to September 1950

By PORTER HART, V. P. Supervising Operating Division

1. Constitution Committee

At the meeting of the Executive Committee of the ISA held in Chicago on February 10th, 1950, J. B. McMahon was appointed the new Chairman of the Constitution Committee in order to expedite the work of getting the Constitution in shape to submit to the Board of Directors of the Society in September. Members of this committee are C. C. Vogt, Washington Section; G. A. Ehly, Philadelphia Section; R. Roberts, New Jersey Section; J. Johnson, Philadelphia Section. Also assisting this committee were the Executive Committee and Executive Committee's past members.

The Constitution Committee's work since this date has been reviewed at the Executive Committee Meeting in Detroit, July 28th. It was agreed that the Constitution, with a few minor changes, would be ready to be turned over to the Structure and Planning Committee and to be presented to the ISA Board of Directors in September. The work of the past Constitution Committee headed by Mr. Rieger, was very helpful to the new Constitution Committee in that they had done some of the background work. It is very urgent that the affairs of the Instrument Society be straightened out so it can operate on a more legitimate basis.

2. Finance Committee

The Executive Committee was brought up to date on this committee's activities in their meeting in Detroit, July 28th, through a report made personally by Mr. George R. Feeley, Chairman. In the report of this committee a few minor changes were recommended and Mr. Feeley will make these changes and have the report in its final form by August 15th, covering the 1951 Budget.

3. Publications Committee

The Publications Committee (L. H. Allen, Chairman) has been in an uncertain position for some time. The Preliminary Report on the ISA Journal prepared by L. H. Allen was presented personally on June 15th at the Executive Committee Meeting in Houston, Texas. At this time Mr. Allen was requested to submit suggestions for members of this committee and to make some revisions so his report could be submitted for final approval.

In Mr. Allen's report he suggested that the first page of the ISA Journal should have a cover in color showing the ISA symbol with the National Officers and ISA Committee Chairmen along with a Table of Contents for the particular issue. The Instruments Publishing Company has agreed to furnish this gratis for the remainder of the current year, but if it is to be continued funds will have to be supplied for this addition.

It is the feeling of Mr. Allen and the Executive Committee that should the ISA decide to publish their own journal, it would be necessary for $80,000 to $100,000 be set aside for that purpose. A good proportion of this sum would be spent without return during the planning period of six months to one year, which time would be required to set up the organization necessary to operate such a publication.

4. Meetings Committee

At the Executive Committee meeting of February 10th, 1950, in Chicago, the Executive Committee resolved that the Board of Directors of the Society should place in the hands of its Executive Committee the determination of locations for future National Conferences and Exhibits. This proposal is considered necessary to permit forming a long-range meetings policy. To follow up the advisability of this change it was proposed that the Meetings and Finance Committees get together in conjunction with the Exhibit Manager and make a report as to the aspects of future Conferences and Exhibits, primarily to select a sight for '52, and the future locations which will be to the best interest of the ISA, both financially and according to estimated attendance. The Executive Secretary prepared a chart showing the possibilities of successful meetings in fourteen different cities. This report was reviewed by the Meetings and Finance Committees and they have presented a proposed schedule for the Society to establish a five-year program between New York, Philadelphia, Cleveland and Chicago, on the 5th year meeting's site to be determined at a location which will be to the best interests of the Society. The Executive Committee recommends that the ISA Board of Directors place into its control the selection of locations for the National Conference and Exhibit.

W. H. Fortney and the Houston Section have been very active in making arrangements for the 1951 Conference and Exhibit and an announcement luncheon was held in Houston in June, in which approximately 100 Gulf Coast executives attended to make public our plans for the 6th National Instrument Society Conference and Exhibit, which will be held in Houston in 1951.

THE SECRETARY'S PAGE

Richard Rimbach

Fifth Anniversary Membership Campaign

Five thousand members of the Instrument Society of America in 1951. This is the membership goal for the Fifth Anniversary of the Society, which is in April 1951.

Membership now totals 4382, so that to reach our objective we must add 618 new members in the next six months, or only two members per section per month.

618 new members in six months means 103 a month. Therefore if only a small portion of our present membership takes an active interest in the campaign, we will reach our objective. If a large proportion gives its services, we will go over the top in less than three months. Surely every member knows at least one individual who, if properly approached, will make a valuable addition to our membership and will also reap the many benefits which ISA members receive.

The first step in this campaign has been started by M. S. Jacobs, Chairman of the National Membership Committee. He is asking the 52 local Sections to take a census of all instrument engineers and instrument men in their respective geographical areas. "Miff" Jacobs is also asking local Sections to organize membership committees on a larger scale than ever before. Such committees should be large, with one committee member on the staff of each employer in the area.

The National Membership Committee will meet with the local Section membership committees and offer any assistance in meeting our membership goal. At these meetings there will be an interchange of information in regard to membership solicitation methods that have been found effective.

The declared goal can and will be reached if every member does his part. If you are not serving your Society in some official capacity, here is an excellent opportunity for you to do something to advance the status of instrument men. Who among your associates and friends are not members now?

START SELLING THEM TODAY.

REGIONAL MEETINGS

New Jersey Section, April 3, 1951
Essex House Hotel, Newark, N. J.
"Panel Board Design"

The symposium will develop the "philosophy" of panel board design by speakers from various industries: process industry; utility, both steam generator and electric; aircraft test and operating panels; panel economics from fabricators point of view.

Symposium starts at 2 P.M. and will resume after dinner in the evening.

—**W. D. Archibald, 605 Westminster Ave., Elizabeth 3, N. J. Secretary, ISA New Jersey Section.**

—o—

New York Section, January 26-27, 1951
Hotel New Yorker, New York City
"Process Control"

General Meeting from 9:00 A.M. to 5:00 P.M. January 26th and on the 27th there will be a display and discussion by manufacturers of instruments and equipment used by industry in process control. There will be a dinner on Friday evening.

—**C. J. Zellner, 708 First Avenue, New York 17, N. Y.**

—o—

Pittsburgh Section jointly with the Carnegie Institute of Technology, Electrical, Mechanical and Metallurgical Departments, March 28-30, 1951. Roosevelt Hotel, Pittsburgh, Pa.

"Instrumentation For Metals Industry"

Primary aims of this conference are to point up the rapid advances in instrumentation techniques and to demonstrate the advantages of modern instrumentation as a means of increasing production, reducing costs and improving product quality.

Following Pittsburgh Local Sections are cooperating: ACS, AIEE, AIME, ASME, ASM, ASTE, ASTM, and the AWS.

—**L. L. Susany, Carnegie Institute, 4400 Forbes St., Pittsburgh, Pa.**

TEN WAYS TO KILL A SOCIETY*

(National or Local Section)

1. Don't come to the meetings.
2. But if you do come, come late.
3. If the weather doesn't suit you, don't think of coming.
4. If you don't attend, find fault with the work of the officers and other members.
5. Never accept an office, as it is easier to criticize than to do things.
6. Nevertheless, get sore if you are not appointed on a committee, but if you are, don't attend the committee meetings.
7. If asked by the chairman to give your opinion regarding some important matter, tell him you have nothing to say. After the meeting tell everyone how things ought to be done.
8. Do nothing more than is absolutely necessary, but when other members roll up their sleeves and willingly and unselfishly use their ability to help matters along, howl that the association is run by a clique.
9. Hold back your dues as long as possible, or don't pay at all.
10. Don't bother about getting new members, let the other fellow do it.

*Reprinted from "*The ISA Bulletin*," September, 1950, Aruba Section Publication.

Houston Instrument Convention Committee Organizes

At a meeting of the Houston Section Committee of the Instrument Society of America on October 10th plans were discussed for the Sixth National Instrument Conference and Exhibit to be held in the Sam Houston Coliseum, September 10-14, 1951.

The following were present: Seated, left to right: Dale Mattix, Cities Service Corp., Lake Charles, La.; C. R. Miller, General Tire and Rubber Co., Baytown, Texas; M. J. O'Neal, Shell Oil Co., Houston, Texas (President, Gulf Coast Spectroscopic Group); C. W. Bates, Humble Oil & Refining Co., Baytown, Texas; Prof. G. L. Farrar, Department of Chemical Engineering, A & M College of Texas; (Chairman of Steering Committee for Symposium on Instrumentation for Process Industries); M. K. Anderson, Carbide and Carbon Chemical Co., Texas City, Texas; W. H. Fortney, Humble Oil & Refining Co., Baytown, Texas (Chairman Houston I.S.A. 1951 Convention Committee); Paul H. Buehner, Convention Manager, Houston Chamber of Commerce.

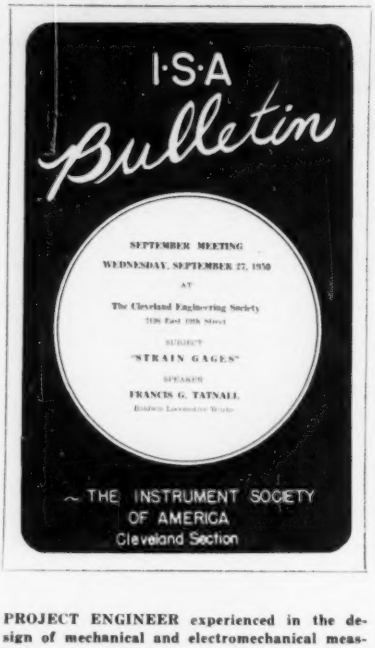
Standing (left to right) are: W. B. Rawson, Vice President, Maintenance Engineering Corp., Houston, Texas; A. Costa, Westcott and Greis, Houston, Texas; R. E. Hanson, Leeds and Northrup Co., Houston, Texas; E. E. Kleir, Foxboro Co., Houston, Texas; R. L. Nichols, Magnolia Petroleum Co., Beaumont, Texas; C. L. Garner, Garner Instrument Co., San Antonio, Texas; L. C. Books, Shell Oil Co., Houston, Texas; I. K. Farley, Brown Instrument Div., Houston, Texas; Richard Rimbach, Executive Secretary, I.S.A., Pittsburgh.

A New Local Section Publication

At the right is an illustration of the front cover of the first issue of the new publication of the Cleveland Section, the *ISA Bulletin*. The *Bulletin* is the newest addition to the family of eight multiple-page publications issued by local Sections of the Society. The seven other Sections who publish such a pamphlet are the Aruba, Chicago, Detroit, New York, Niagara Frontier, Pittsburgh and Washington Sections.

The Cleveland *Bulletin* measures 5.5 by 8.5 inches, is printed on slick paper, runs to 8 pages and achieved a circulation of 500 with the first issue in September of this year. The first two issues each contained 2.5 pages of advertising, the final goal being 4.5 pages in an 8 page issue. Present editor of the *Bulletin* is J. C. Moise of the Case Institute of Technology.

In addition to running two full pages per issue announcing the coming meeting and giving detailed speaker and subject information, a title page has appeared listing the Section Officers, the Standing Committee Chairmen and the Technical Subcommittees with their Chairmen. A complete Section membership list was published in the September issue and a Section Employment Committee Report appeared in the October issue.



Concerning the Employment Committee—space is available in the *Bulletin* for this committee to run notices of positions available or positions wanted. This service will be free of cost to members of the Section or to any company in the Cleveland area seeking instrument men.

As E. C. Baran, President of the Cleveland Section, wrote in "The President's Message" in the first issue: "This publication indicates progress is being made in our attempt to provide greater benefits for our membership. We have a means of keeping the membership informed as to the progress of its Society. Thanks are certainly due those members who gave, and will give, so unselfishly of both time and effort to make this *ISA Bulletin* a reality for the good of the entire Section and the Society."

ISA EMPLOYMENT SERVICE

Forward your letter to INSTRUMENT SOCIETY OF AMERICA, 921 Ridge Ave., Pittsburgh 12, Pa.

SENIOR DRAFTSMEN, DESIGNERS, CHECKERS (11 Openings) for Instrument Piping Div. of large corporation. Must have not less than six years experience in instrument piping field. Give complete details of background, education and experience in first letter. All transportation costs will be refunded to those invited for interview and living at a distance of more than fifty miles from New York. Transportation costs will cover moving and household possessions of successful applicants. Location N. Y. City. Box 389.

INSTRUMENT ENGINEER. Education B. S. in Mechanical or Chemical Engineering preferable but not mandatory. Training and experience must be such as to qualify applicant to select proper process control units for maintaining proper conditions of temperature, pressure, flow, etc.; write specifications for obtaining bids; analyze bids and select suppliers; make layout arrangements of units. Wide knowledge required of process principles and operations; types and makes of instruments and instrument control theory and applications. Location Pittsburgh, Pa. Box 390.

DEVELOPMENT ENGINEER. Excellent opportunity open with nationally known manufacturer of temperature and pressure responsive instruments. Should have either M. E. or E. E. degree; experience with Bourdon tubes and diaphragms desirable. Give full details of background in first letter. Location Milwaukee, Wis. Box 391.

CONTROL VALVE DESIGNER preferably young graduate engineer with some related experience. Exceptional opportunity to grow with progressive nationally-known company. Location Hamilton, Ohio. Box 392.

MECHANICAL DESIGN ENGINEER. Drafting board work involving the design of new mechanical and electromechanical instruments. Thorough understanding of the application of small gear trains, motors, levers and associated components required. Preferably college graduate with Engineering Degree. Location Baltimore, Md. Box 393.

PROJECT ENGINEER experienced in the design of mechanical and electromechanical measuring instruments. Give details of experience in first letter. Location Baltimore, Md. Box 394.

PHYSICIST with Masters Degree and preferably Ph. D. degree for development work principally in the fields of humidity and temperature measurements. Should have several years experience in industrial work. Location Baltimore, Md. Box 395.

INSTRUMENT ENGINEERS (three) engineering graduates with experience that would qualify for one or all fields of hydraulic, electronic and mechanical instrumentation. Salary approximately $500.00 per month depending on qualifications. Location New Jersey. Box 396.

SALES ENGINEER age 25 to 40 with car to travel Western New York State doing sales application engineering work for established line of pressure and temperature indicators and controllers. Sales experience necessary, instrumentation background desirable. Box 397.

INSTRUMENT MECHANICS (two) with experience in maintenance, repair and installation of hydraulic, electronic and mechanical instruments. Rate $2.00 hr. Give details of experience in first letter. Location New Jersey. Box 398.

INSTRUMENT MAN must be First Class and thoroughly familiar with installations, repairs, and trouble shooting of refinery instruments and controls. Steady employment, some shift work. Location New Jersey. Box 399.

INSTRUMENT MECHANIC must be thoroughly experienced in repair and maintenance of instruments in chemical plant. Give details of experience in first letter. Location Akron, Ohio. Box 400.

INSTRUMENT MECHANICS field jobs, installation, calibration, maintenance, and repair of pyrometers, meters and gages (mechanical, electric and electronic) utilized in high pressure refinery. Rates $1.97 to $2.26 per hour. Location Eastern Pennsylvania. Box 401.

CHIEF INSTRUMENT ENGINEER to head Instrument Dep't of Alcohol Plant now preparing to commence operations. Must be experienced in process instrumentation. Instruments consists of 70 recorders, flow meters, flow controllers, level indicators, pH meters, etc. Make of instruments are Bristol, Taylor, Brown, Leeds & Northrup and Foxboro. Give complete details of education and experience in first letter. Location Omaha, Nebraska. Box 402.

PROFESSIONAL VACANCIES

The U. S. Naval Ordnance Test Station, Inyokern, California has announced vacancies as listed below.

For Application Forms and information write to J. B. Hamilton, Head, Professional Placement Branch, U. S. Naval Ordnance Test Station, Inyokern, China Lake, California.

PHYSICIST GS-11, $5400/annum. Position: Instrument Development, Test Department. Duties: Responsibility for the theoretical design and development of a wide variety of specialized photographic and optical equipment and instrumentation. Requirements: Degree in Physics and several years experience in specialized design and development and instrumentation.

ELECTRONIC ENGINEER GS-12, $6400/annum. Position: Head of Radar Section, Metric Electronics. Branch, Instrument Operations, Test Dep't. Duties: Responsible for all aspects of radar operation on ballistics ground ranges. Design and development of electronic instruments and equipment. Requirements: Thorough background in radar. Working knowledge of photography, physics and general engineering.

ELECTRONIC ENGINEER GS-11, $5400/annum. Position: Test Department, Instrument Operations, Metric Electronics. Duties: Group leader for research, design, development and operation of electronic devices for use in Telemetering, Doppler, Magnetic Pick-up, and Guided Missiles.

ELECTRONIC ENGINEER GS-11, $5400/annum. Position: Instrument Development, Test Dep't. Duties: Task supervisor of specialized Radar problems in a scientific research program. Includes coordination of the effort of several scientific task groups in varied phases of electronic test and development work. Requirement: Several years experience above B. S. Degree in the technical field as well as ability to evaluate and direct a scientific test and development program.

ELECTRONIC ENGINEER GS-9, $4600/annum. Position: Instrument Operation, Test Dep't. Duties: Electronic research and development in the field of measurement. Requirements: B. S. Degree in electrical or electronic engineering with at least 2 years experience in the field.

Section Secretaries, Meeting Data and Programs

AKRON
Fred Appel, 932 Columbia Ct., Barberton, Ohio. Tel: SH 3440
Fourth Tuesday, Meeting at 7:30 P. M., Akron Y.W.C.A.
Nov. 28, "Principles of Automatic Control," ISA color and sound film by G. F. Akins, J. Kowalski, Eastman Kodak Co.

ALBUQUERQUE
E. J. Burda, Sandia Corp., P. O. Box 5800, Albuquerque, N. Mex.
First Monday, Meeting at 8:00 P.M., Science Lecture Hall, Univ. of N. M.

ARUBA
K. H. Walker, P. O. Box 389, c/o Lago Oil & Transport Co., Ltd., Aruba, N.W.I.
First Tuesday, Meeting at 7:15 P. M., Engr's Club.

ATLANTA
H. Kockritz, Fischer & Porter Co., 84 Peachtree St., Atlanta, Ga. Tel: CY 1269
Fourth Monday, Meeting at 7:45 P.M., Ga. Institute of Technology.

BALTIMORE
W. A. Dickinson, 2716 Dunbrook Ct., Baltimore 22, Md. Tel. Dundalk 2272J
Second Friday, Meeting at 8:00 P.M., Engr's. Club of Baltimore.

BATON ROUGE
John Q. Bass, 1517 Longwood Dr., Baton Rouge, La. Tel: 3-0283
Meeting monthly, no definite time, L.S.U. Physics Bldg.

BOSTON
Stephen E. Lord, 60 Braintree Ave., Quincy 69, Mass. Tel: MA 9-1066
Last Wednesday, Dinner at 6:30 P. M., Meeting at 7:00 P.M., 99 Club, 99 State St.

CALIFORNIA
D. C. Duncan, Helipot Corp., 916 Meridian Ave., S. Pasadena, Calif. Tel: SY 4-8489
Second Wednesday, Dinner at 6:30 P. M. Meeting at 8:00 P.M., Carolina Dines.

CENTRAL ILLINOIS
Thomas A. Carroll, 721 Hurlburt St., Peoria 6, Ill. Tel.: Peoria 4-8909
First Wednesday, Dinner at 6:30 P.M., Meeting at 7:30 P.M.

CENTRAL INDIANA
Richard F. Rieman, 3550 Euclid St., Indianapolis, Ind. Tel. CH 7462
First Tuesday, Meeting at 7:30 P. M.

CENTRAL NEW YORK
Karl W. Robertson, Minneapolis-Honeywell Reg. Co., 121 W. Onondaga St., Syracuse, New York.

CHARLESTON
Clayton A. Williams, 303 E. 9th St., Belle, W. Va. Tel: 927871
First Monday, Dinner at 6:15 P.M., Meeting at 8:00 P.M., Kanawha Hotel
Dec. 4, "Principles of Automatic Control," ISA color and sound film by G. F. Akins, J. Kowalski, Eastman Kodak Co.

CHICAGO
Floyd E. Ertaman, Rm. 1420 Fisher Bldg., 343 S. Dearborn St., Chicago 4, Ill. Tel: WE 9-0686
First Monday, Dinner at 6:30 P. M., Meeting at 8:00 P. M., Shoreland Hotel.
Dec. 4, Subject: "Control Theory," N. B. Nichols, U. of Minnesota.
Educational Series on Pyrometry at Chicago Vocational School:
Nov. 27, "Electronic Potentiometers—No. 2."
Dec. 11, "Calibration Methods."

CHINA LAKE
A. H. Staud, 1004 Michelson Lab., USNOTS, China Lake, Calif. Tel: 77882
Fourth Thursday, Meeting at 8:00 P.M., Michelson Lab, USNOTS.

CINCINNATI
L. W. Greene, 181 Market St., Aurora, Ind.
First Monday, Meeting at 8:00 P.M., Eng'r. Society Hqs.

CLEVELAND
A. E. Ehrke, 1732 East 291st St., Wickliffe, Ohio. Tel: WI 3-1036
Fourth Wednesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Cleveland Eng'r. Society, E. 19th St.

COLUMBUS
W. C. Myers, c/o Battelle Memorial Institute, 505 King Ave., Columbus, Ohio. Tel: UN 3191, Ex. 248
Third Thursday, Meeting at 8:00 P.M., Battelle Auditorium

CUMBERLAND
Clyde Babst, 225 Cecilia St., Cumberland, Md. Tel: 583-W
Tuesday after Fourth Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Algonquin Hotel.
Nov. 28: "The Saunders Type Valve," R. J. Kidde, Hills McCanna Co., Chicago, Ill.

DETROIT
A. W. Brueckner, 5556 S. Clarendon Ave., Detroit 4, Mich. Tel: TYler 6-9511.
Third Tuesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Rackham Bldg.
Nov. 21, Subject: "Temperature Measurements in Test Dynamometers."
Dec. 18, Social Meeting.

EASTERN NEW YORK
W. R. McKegg, c/o Gen. Engrg. & Consulting Lab., G. E. Co., Schenectady, N. Y.
First Tuesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M.

GULF COAST
W. N. Sloan, E. I. Du Pont de Nemours & Co., Orange, Texas. Tel: 8411 Ext. 444
Third Tuesday. Meeting at 7:30 P.M., Lamar College, Beaumont, Texas.
Nov. 21, "Principles of Automatic Control," ISA color and sound film by G. F. Akins, J. Kowalski, Eastman Kodak Co.

HOUSTON
I. K. Farley, 2123 Travis St., Houston, Texas, Tel: Charter 2511.
Last Monday, Meeting at 8:00 P.M., Engineers Club.
Nov. 27, "Principles of Automatic Control," ISA color and sound film by G. F. Akins, J. Kowalski, Eastman Kodak Co.

KANSAS CITY
L. E. Oberhelman, Standard Oil Co., Sugar Creek, Mo. Tel: MU 1227
First Tuesday, Meeting at 7:30 P.M., Univ. of Kansas City.
Dec. 5, "Control Valves," D. P. Eckman, Conoflow Corp.

LOUISVILLE
H. C. Scherffius, 980 Palatka Rd., Louisville 8, Ky. Tel: Franklin 1265
Fourth Tuesday, Meeting at 8:00 P.M., Seagram Auditorium.

MONTREAL
S. J. Mizuhara, 1075 Allard, Verdun, Quebec, Canada. Tel: TR 3252
Last Monday, Meeting at 8:00 P.M. Mechanics' Institute.
Dec. 11, "Principles of Automatic Control," ISA color and sound film by G. F. Akins, J. Kowalski, Eastman Kodak Co.

NEW JERSEY
Fred L. Crabbe, Malcolm W. Black & Co., Inc., 41 East 42nd St., New York 17, N. Y. Tel: Vanderbilt 6-2960.
First Tuesday, Dinner at 6:00 P. M. Meeting at 8:00 P.M., Essex House, Newark.
Nov. 20, Joint Meeting with New York Section, Hobnob Club, N.Y.C., Subject: "Natural Gas for New York."

NEW ORLEANS
W. H. Haney, 2927 Music St., New Orleans 22, La.
No Regular Date, Meeting at 8:00 P.M.

NEW YORK
F. B. Leslie, 8856 Commonwealth Blvd., Bellerose 6, N. Y. Tel: FI 7-0645
Last Monday, Dinner at 6:00 P.M., Meeting at 7:45 P.M., Henry Hudson Hotel.
Nov. 20, Joint meeting with New Jersey Section, Hobnob Club, Subject: "Natural Gas for New York."
Jan. 26, 27, Annual Regional Conference, Hotel New Yorker. Four Sessions on Modern Process Controllers.

J. E. Allen

The Baltimore Section, ISA, sorrowfully announces the death of one of its members, J. E. Allen of Lancaster, Pa. Mr. Allen, a member since October of 1946, died August 6, 1950.

John H. Dillon

It is with deep regret that the New York Section announces the passing of their member, John H. Dillon, Sales Engineer of the Moeller Instrument Company. Mr. Dillon had been a member of the New York Section since September 1947.

NIAGARA FRONTIER
Mrs. James L. Martin, 697 Potomac Ave., Buffalo 9, N. Y. Tel: GR 1450
Fourth Monday, Dinner at 6:00 P.M., Meeting at 8:00 P.M., N. Y. State Inst. of Arts and Sciences, Buffalo.
Nov. 27, "The Application of Electronic Techniques to Instrumentation," F. L. Maltby, The Bristol Co., Waterbury, Conn.

NORTH TEXAS
R. E. Byers, 6000 Lemmon Ave., Dallas 9, Texas

NORTHERN CALIFORNIA
M. A. Dimmick, 5607 Alta Punta, El Cerrito, Calif. Tel: Be 5-1095
Third Monday, Meeting at 7:30 P.M., Angelo's, Emeryville.
Nov. 20, Union League Club, San Fran., "Vibration Excitation and Measurements," R. W. Weld, Pacific Scientific Co.
Dec. 18, Spenger's Grotto, Berkeley, "Pressure Regulation & Regulators," T. E. Gannon, Grove Reg. Co.

NORTHERN INDIANA
J. Baum Beckman, 547 N. Waller Ave., Chicago 44, Ill. Tel: ES 8-7776
Third Wednesday, Dinner at 6:30 P.M., Meeting at 7:30 P.M., Gary Y.M.C.A.

OAK RIDGE
John H. Clark, 230 Canton Hall, Oak Ridge, Tenn. Tel: 5-9142
First Wednesday, Dinner at 6:30 P.M., Meeting at 7:30 P.M., Oak Terrace.

ONTARIO
John W. Huether, 311 Southerland Dr., Leaside, Ontario, Canada. Tel: HU-7114
Meeting at 8:00 P.M.
Third Thursday, Meeting at 8:00 P.M. Friendship Hall, College St. United Church, Toronto

PANHANDLE
R. E. Harris, 228 Maya Bldg., Amarillo, Texas. Tel.: 31434.
Third Tuesday, Meeting at 8:00 P.M.

PHILADELPHIA
C. W. Wood, 6908 Market St., Upper Darby, Pa. Tel: Clearbrook 9-3959
Third Wednesday, Meeting at 8:00 P.M., Bellvue Stratford Hotel.
Nov. 28, Joint Meeting with ASME, Engineers Club.

PITTSBURGH
Miss Louise Suckfield, P.O. Box 2038, Pittsburgh 30, Pa. Tel: HI 1-1800
Fourth Monday, meeting jointly with the Technical Committee on Inspection and Gaging. Dinner at 6:30 P.M., Meetings at 8:00 P.M., Roosevelt Hotel.
Nov. 20, "Instrumentation in an Atomic Power Plant," C. A. Hansen, Jr., General Electric Co. "Management's Viewpoint on Inspection," P. H. Startzman, Oliver Iron & Steel Co.
Dec. 18, Christmas Party.

PRESQUE ISLE
Edwin P. Schuwerk, 445½ Halley St., L. P., Erie, Pa. Tel: 2-3349
Fourth Tuesday, Meeting at 8:00 P.M., G. E. Community Center, East Lake Rd., Erie, Pa.

RICHLAND
R. A. Nederhood, 2003 Trippe, Richland, Washington. Tel. 5-4442
Second Wednesday, Meeting at 7:30 P.M., American Legion Hall.

ROCHESTER
R. C. Schwarz, Jr., 1201 Granite Bldg., Rochester 4, N. Y. Tel: Monroe 4610R
Fourth Tuesday, Meeting at 8:00 P.M., Univ. of Rochester, Physics Lecture Hall.

SARNIA
J. J. Connors, 272 Elgin St., Sarnia, Ontario, Canada. Tel: 1970 W
Second Friday, Meeting at 8:00 P.M., Moose Hall.

SOUTH BEND
Sam M. Rouse, 436 Moccasin Ave., Buchanan, Mich. Tel: 678
First Thursday, Meeting at 8:00 P.M., Engineers Club, Hotel La Salle, South Bend.

SOUTH MICHIGAN
W. J. Sprau, 2509 S. Rose St., Kalamazoo, Mich. Tel: 4-7012.
Fourth Wednesday, Dinner at 6:30 P.M. Meeting at 8:00 P.M., Chicken Charlie's, Kalamazoo.

SOUTH TEXAS
H. C. Givens, La Gloria Corp., P.O. 637, Falfurrias, Texas. Tel: 122-W
First Thursday, Meeting at 7:30 P.M., Garner Aircraft Instrument School.

ST. LOUIS
W. G. Lee, 4710 Delor St., St. Louis 16, Mo. Tel: FL 8516
First Wednesday, Meeting at 8:00 P.M., Engineer's Club of St. Louis.
Dec. 6, "Control Valves," D. P. Eckman, Conoflow Corp.

TOLEDO
Morris L. Conner, 925½ Sherman St., Toledo, Ohio. Tel: MA 9403
Third Tuesday, Meeting at 8:00 P. M., Service Bldg., Toledo Edison Co.

TENNESSEE
N. M. Taylor, 16 Edgewood, Kingsport, Tenn. Tel: 3-538J
No definite night, Dinner at 6:45 P.M., Meeting at 8:00 P.M., Hall's Dining Rm., Bristol Hwy., Kingsport.

TULSA
J. J. Fox, Phillips Petroleum Co., Phillips Bldg., Bartlesville, Okla. Tel: 6600 Ext. 501.
First Monday, Meeting at 7:30 P.M., Engineering Bldg., Tulsa Univ.
Dec. 4, "Control Valves," D. P. Eckman, Conoflow Corp.

TWIN CITIES
Alden Hine, c/o Pinkney & Hine, 552 Plymouth Bldg., Minneapolis 3, Minn. Tel.: Lincoln 0523.
Fourth Tuesday, Dinner at 6:30 P.M. Coffman Memorial Union, U. of Minn.
Dec. 12, "Principles of Automatic Control," ISA color and sound film by G. F. Akins, J. Kowalski, Eastman Kodak Co.

WASHINGTON
Raymond E. Miller, 20-224 Naval Ord. Lab., White Oak, Md. Tel: JU 7-6742
Third Monday, Meeting at 8:00 P.M., P. I. P. Co. Auditorium.

WAYNE COUNTY
Robert Karr, 2455 Biddle Ave., Wyandotte, Michigan. Tel. 0167J
Third Monday, Meeting at 8:00 P.M., Larson's Cafe, Lincoln Park, Mich.

WILMINGTON
Dean Valentine, 34 N. Hill Drive, West Chester, Pa. Tel: 0293W
Third Tuesday, Meeting at 8:00 P.M. Harlan Public School, Wilm.
Nov. 21, "Duragauge Transmitters," Geo. Keating, Manning, Maxwell & Moore, Inc.

Uses of Magnetic Tape Recording in Telemetering

By KENNETH B. BOOTHE*

During the past few years, significant improvements have been made in the technique of magnetic tape recording. Although this method was first regarded with some degree of skepticism, it is now universally recognized as the most satisfactory means for recording high fidelity sound. Due to several more recent improvements, however, many new applications have been found for this medium which far exceed the requirements for sound recording alone.

One of the most promising of these new applications is in the field of FM-FM telemetering. In this system, a number of sensory elements are used to pick up and translate various types of information into electrical terms. These quantities to be measured are transmitted simultaneously over a wire or radio link. Each instrument variation causes a proportional change in the frequency of a corresponding sub-carrier oscillator. When radio transmission is used, these frequency-modulated signals are mixed and the composite signal frequency-modulates an R.F. carrier. Hence the term FM-FM telemetering, which is a system that is being used extensively in aircraft and in other mobile testing.

The R.F. signal is demodulated at the receiving station and the composite signal is recorded directly by a suitable method of storing and reproducing this data. During the reproduction process, the composite signal may be separated into the original frequency bands of intelligence by means of band-pass filters. Each channel which has thus been separated may be fed into its associated amplitude saturated limiter and FM discriminator.

As amplitude information, the output of the discriminator may be connected to direct reading instruments showing the instantaneous value of the instrumented intelligence. Photographic or oscillographic records may also be made for historical or study purpose.

Such a recording system must be extremely accurate and dependable and must also afford a flexible means for reproducing particular sections of information for detailed analysis.

Another important requirement is imposed on the recorder by the very small frequency deviations used in FM-FM telemetering. Due to the rather limited frequency spectrum available on a single radio link, each sub-carrier of the composite signal, in most cases, is deviated by only ± 7.5 per cent of the sub-carrier center frequency. In this way, as many as fourteen or fifteen-sub-carriers may be used simultaneously on one R.F. carrier. However, the signal-to-noise ratio obtainable with a recorder is equal to the ratio of maximum per cent frequency deviation to per cent peak flutter. With such small frequency deviations, it may be readily seen that the recorder and reproducer must be basically free from flutter and wow as the art permits.

The recorder must also have a very large dynamic range, plus the ability to record a wide band of frequencies with a negligible amount of distortion. Standard telemetering sub-carrier channels cover a band from about 350 cycles to more than 30,000 cycles and, since they must be recorded simultaneously, low distortion is an important factor in avoiding cross-modulation.

One outstanding advantage of magnetic tape recording is its frequency response which is better than 1000 cycles per inch per second of tape speed. In other words, tapes running at fifteen inches per second have a response beyond 15,000 cycles and at 30 inches per second, beyond 30,000 cycles. Drive mechanisms have already been developed to run tapes at 60 inches per second for a response of better than 60,000 cycles. Furthermore, if there should ever be an actual need for higher frequencies, 200 K.C. or more appears to be entirely possible. Increasing the frequency response, however, means increasing the tape speed which reduces the total playing time. For all practical purposes, 30 or 60 inches per second seems to be quite adequate for telemetering applications.

Harmonic distortion in magnetic recording is extremely low due to the cancellation effect on all even order harmonics. The remaining distortion is almost entirely third harmonic which is of a negligible amount.

With improved tapes that are now available, dynamic ranges of over 60 d.b. are quite easy to obtain with high quality sound recording equipment.

For data reduction and analysis purposes, no recording medium has yet been able to match the flexibility and economy of magnetic tape. In order to fully appreciate these tremendous advantages, it must be realized that all fourteen or fifteen telemetering channels may be simultaneously recorded and reproduced on a single quarter inch tape. Furthermore, only one record and one playback head is employed for this purpose.

Due to amplitude changes which are caused by inconsistencies in magnetic tape coating material, direct amplitude data recording must be avoided in order to obtain any degree of accuracy. Although such level variations are too small and too short a duration to be of any importance in sound recording, the instantaneous value of these variations may result in a fifty or sixty per cent loss in amplitude. This seriously affects the accuracy of oscillographic records and becomes increasingly serious at the higher frequencies. Additional errors are introduced in amplitude recording because of phase shift which occurs at the upper and lower limits of the frequency spectrum. Fortunately, these two basic disadvantages may be easily overcome with the aforementioned FM carrier application.

Entire flight information from an aircraft test may be recorded on mobile field equipment and may be later brought back to a fixed ground station for playback. In this manner, a single portable recorder and associated receiver, which costs a fraction of a complete ground station, may be employed with each test. By playing back the previously recorded tapes, one at a time, one ground station can serve many times its normal capacity.

If photographic or oscillographic records are required, the section of tape containing the desired information can be played back repeatedly until optimum records are obtained. For detailed analysis, it is possible to dub off a single information channel to a second recorder. By making a continuous loop of the copied track, the information data can be repeated indefinitely. The dubbing method is suggested in order to protect the original tape which may have other channels of information that must be kept intact.

Magnetic tape can be repeatedly erased and reused and can also be monitored while the recording process is taking place.

*Audio & Video Products Corp., N. Y. 19, N. Y.

Note:—Presented at the Fifth Annual Conference of the Instrument Society of America, Sept. 18-22, 1950, Buffalo, N. Y.

Statements and opinions advanced in papers are to be understood as individual expressions of the authors and not those of the Society.

Tape has the additional advantage of a large capacity to store information in a compact space. The standard NAB 10.5 in. reel contains 2400 ft. of one quarter inch tape which stores 32 minutes of data at the 15 inch speed and 16 minutes of information at the 30 inch speed.

The Ampex model 302 was specifically developed for use in telemetering re-recording. However, it has many other applications which will be mentioned later. With the exception of certain modifications in the electrical circuitry, head design and mechanical drive, it is identical to the Ampex model 300, which has enjoyed such wide success in the field of sound recording. Due to the close similarity of these two models, much of the high production costs which would normally be expected for any new development, have already been absorbed by the Model 300.

The frequency response of the Model 302 at the 30 inch per second speed is flat within plus or minus 2 db. from 50 to 30,000 cycles and is down no more than 10 db. at 50 kc.

Unlike sound recording, the distribution of telemetering energy is uniform across the frequency spectrum. Therefore, a constant current recording characteristic has been employed with the Model 302. Any pre-emphasis at this point would saturate the tape at the higher frequencies. Since some telemetering frequencies may be as high as 40 or 50 kc., the bias and erase frequency has been moved up to 160 kc. in order to avoid beats between the information data and the bias current. Tests have been made by recording frequencies up to 75 kc. without any detectable beats.

The Model 302 has already been studied and tested in operation with FM-FM telemetering systems by several different agencies. The Raytheon Company has recorded four different channels of intelligence simultaneously so that the difference could be observed between the oscillographs which were taken directly and those which were taken from the tape playback. With electronic compensation, no detectable difference could be noted.

To obtain accuracies of 1 per cent or better, it has been found necessary to use electronic compensation, such as the type developed by the Raymond Rosen Company, on all FM-FM applications where very small frequency deviations occur. Compensation is achieved by simultaneously mixing and recording one unmodulated, frequency stabilized carrier with the composite carrier. During the tape playback, the compensation carrier, which has been subjected to the same mechanical flutter and wow conditions as the composite carrier, is separated from the information channels by means of the usual band pass filter, limiter, and discriminator. The output of the compensation discriminator is then fed at opposite phase and at almost equal amplitude across the outputs of each separate information channel so that their wow and flutter components may be effectively cancelled out.

The basic reason for electronic compensation is to remove the small degree of low frequency wow that cannot be entirely eliminated from the tape recorder by mechanical damping. With electronic compensation, mechanical wow can be effectively reduced by a factor of 5 or 6 which is more than adequate for all practical purposes.

Several studies have been made on the Ampex to ascertain the accuracy which is possible without electronic compensation. The average of all results indicated 2 per cent to be a very conservative figure. Although it appears possible to obtain an accuracy of 1 per cent with a laboratory recorder, this figure cannot be consistently maintained under field conditions. Therefore, compensation must be employed to insure the required accuracy of 1 per cent or better.

At the Applied Physics Laboratory at John Hopkins University, ten channels were recorded simultaneously without compensation covering a range of 1700 to 40,000 cycles. The results were essentially the same as when recording the previously mentioned four band system, at Raytheon.

For field operation, a thoroughly reliable source of 60 cycle supply current is absolutely essential for recording telemetering data. To meet this requirement, Ampex has developed a 60 cycle temperature compensated tuning fork circuit which drives a 60 watt amplifier. The output of the amplifier is connected to the synchronous capstan motor of the recorder which is isolated from any frequency and voltage variations which may occur in the supply source. In actual practice, it has been found advisable to use these amplifiers even when commercial 60 cycle supply current is available. This prevents sudden load changes which may take place on the commercial line from introducing instantaneous motor wow or flutter excursions during the tape recording or playback. The amplifier also has a jack input for an audio oscillator which may be used to generate a variable 60 watt frequency source.

While a great deal of this paper has been devoted to the FM-FM telemetering system of recording, there is much to be said for other applications.

For some time, there has been a definite need for a practical method of recording and reproducing shock and vibration measurements. Inasmuch as this information is of a transient and low frequency nature, phase distortion in the recording medium must again be held at a minimum.

Most shock and vibration data is in the 0 to 1000 cycle range, which is a factor that has previously placed rather serious limitations upon the use of magnetic tape for this particular work. Furthermore, amplitude changes resulting from inconsistencies in tape coating, also offer serious drawbacks.

A brief examination of the foregoing telemetering system, however, reveals that an excellent method for storing transient data has already been developed. This is accomplished by frequency-modulating a 20 or 30 kc. oscillator with shock or vibrations intelligence. By recording these FM changes, it is possible to record all frequencies from dc. to several thousand cycles without regard to amplitude variations or phase shift distortion.

Data of this type may be reproduced in the usual way by feeding the output of the playback amplifier into an AM saturated limiter and discriminator circuit. Accurate oscillographic records may then be made which will show true shock and vibration wave shape and amplitude changes. With the improvements that have been made in discriminators, such as the parallel "T" type, very high linear accuracy and wide band frequency response is relatively easy to achieve with a signal-to-noise ratio of better than 40 db.

A small compact transmitter may also be used under some conditions where it is not desirable to have direct circuit connections between the pick-up or transducer and the recorder. Thus, data may be telemetered out of a small box or crate which is being subjected to shock tests in a rotating tumbling device.

Where requirements exist for recording a number of shock and vibration pick-ups simultaneously, the previously described FM-FM telemetering system with separate frequency modulated oscillators, may be very effectively used.

If the channel frequency response and number of channels are reduced below the usual 14 or 15 required by the standard FM-FM system, a much wider sub-carrier deviation may be used for each intelligence channel. Therefore, a rather large number of 0 to 1000 cycle data channels may be recorded on a single one quarter in. tape. Because of the wider frequency deviation of each sub-carrier, no electronic compensation should be needed to obtain very accurate results.

Additional frequencies, such as time base or marker channels may also be recorded simultaneously with FM channels without interference. During the playback sequence, the AM information may be taken off ahead of the FM limiters and discriminators and separated in the usual way with band-pass filters.

A second system for multi-channel recording incorporates separate record and playback heads, each of which have their own associated record and playback amplifiers. Ampex has successfully developed a recorder of this type using seven separate heads to work with one half inch tape. With one inch tape, 14 heads have also proved to be practical. A combination of separate heads, plus FM/AM carriers for each recording head, offers a tremendous number of channels which may be recorded simultaneously if a sufficient need should ever arise.

A satisfactory method of continuous recording consists of a closed loop of tape which will run for several minutes before repeating its cycle. A device of this type may be very effectively applied to the continuous recording of electrical measurements on a high-voltage power circuit as a means of recording the effects of line faults and other sytem disturbances. Through continuous recording, the conditions proceeding the fault may be recorded as well as the complete history of the fault from its onset to final clearance.

A control device may be incorporated to shut off the recorder just after the fault occurred, leaving a complete history of several minutes preceeding the fault. If no fault occurred, the tape would continue to erase and re-record while awaiting developments.

One of the main objections to the usual recording oscillograph is that it does not start until after the onset of the fault and, therefore, fails to record the beginning and the conditions leading up to the fault.

By employing several modulated carriers, accurate multi-channel oscillographic records may be made, of current, voltage and power measurements.

Magnetic tape recording is also particularly adapted to the storage of binary pulse code information and may be very usefully employed in the speeding up or slowing down of data reduction time. Ratios of 80 or 100 to 1 are relatively easy to accomplish with the drive mechanisms developed by Ampex. By pre-shaping the pulses, one agency has been able to record as many as six hundred to an inch.

The binary code recorder is further simplified because no electronic amplification or bias is necessary. Such a unit consists of a top plate drive assembly plus one record and one playback head. By centertapping the record head, each half of the winding can be fed from separate sources which will permit positive and negative pulses to saturate the tape during positive and negative peaks.

With the basic systems which have already described or developed, perhaps a number of new applications will suggest themselves. You are, therefore, invited to explore the possibilities of magnetic tape as a better method for recording various types of data.

The writer wishes to express his appreciation for the work done by the following agencies whose assistance and cooperation has made the presentation of this paper possible.

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Graphic Instrumentation – A new Tool for Industry

By WALTER S. BOWERS *

A modern control room is the nerve center of a processing unit. It is here that all operating information is received, classified, and acted upon. As in the human body the action, though automatic in normal situations, is carefully supervised when "upsets" occur. In a processing unit "upsets" are a serious problem. A quick reaction on the operator's part can mean the difference between saleable or "off specification" products. By means of a co-ordinated and compact arrangement, the graphic panel helps the operator interpret a condition quickly and provides the fingertip control he needs to cope with the situation. This is its biggest contribution to industry.

In evaluating the graphic control system for three Lube Oil Refining Units at our Lima Refinery, additional advantages considered were: 1. Easier operator training, 2. The savings in control room space, and 3. The overall cost reduction. Against this we weighed the disadvantages of a less flexible board arrangement and the limitation in the type of instruments available. Our investigation of these factors disclosed a number of interesting points which will bear consideration by all potential users. We will also discuss briefly the components we employ, the panel arrangements we prefer, and our maintenance experience to date.

GENERAL FORM AND ARRANGEMENT

When we speak of a graphic panel, we are thinking of a board with all essential process variables controlled from instruments located in a simplified flow diagram painted or fastened on the panel. We prefer either a full length flat panel along the lines of that shown in Fig. 1, or a modified console type similar to the one in Fig. 2. The former shows the board for our Vacuum Distillation Unit which separates crude into lube oil feeds; the latter is a combined control panel for our Solvent Refining and Dewaxing Unit which processes finished blending stocks. Figs. 3 and 4 show rear views of the flat and console type respectively.

In principle, the components which go to make up a graphic system are similar to the conventional instruments which have been used by most industries for years. The actual pieces of equipment are shown schematically in Fig. 5. They are as follows: 1. A pneumatic transmitter, 2. A "blind" (non-indicating, non-recording) receiver controller, 3. An indicating (board mounted) graphic type control station embodying the manual — automatic transfer switch, 4. A multi-point pneumatic recorder, and 5. A diaphragm control valve.

The recently developed recording graphic control station is now being used on our newest graphic panel. This will minimize the need for multi-point recorders and should provide a better operating trend picture.

We have found that the mercuryless transmitter with a "blind" controller mounted at the process generally results in more stable flow control. Where pulsating flows are encountered, the conventional mercury manometer has been preferable. A schematic piping arrangement for this type of installation is shown in Fig. 6.

We have used the force balance transmitter with a blind controller mounted behind the board for measuring many temperatures below 500° F. Essential operating temperatures have been checked and indicated or recorded on multi-point potentiometers. For temperatures above 500° F. or those subject to demands of extreme accuracy and sensitivity, we prefer to use

* Standard Oil Co., Cleveland, Ohio.

Note:—Presented at the Fifth Annual Conference of the Instrument Society of America, Sept. 18-22, 1950, Buffalo, N. Y.

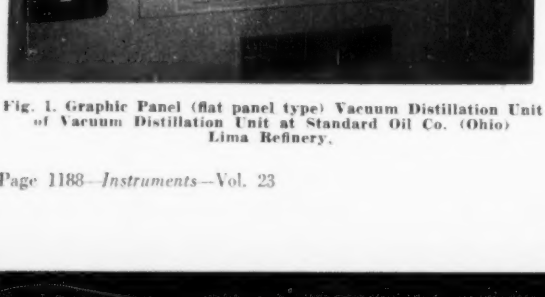


Fig. 1. Graphic Panel (flat panel type) Vacuum Distillation Unit of Vacuum Distillation Unit at Standard Oil Co. (Ohio) Lima Refinery.

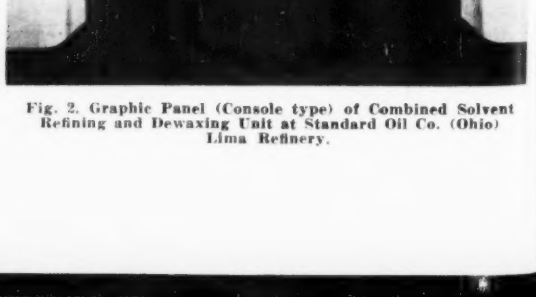


Fig. 2. Graphic Panel (Console type) of Combined Solvent Refining and Dewaxing Unit at Standard Oil Co. (Ohio) Lima Refinery.

recording electronic potentiometer controllers.

In practically all cases we have brought level indications to the board as an aid to the operator. Where control is accomplished from the board, this has been done by using an arrangement similar to that shown in the schematic diagram. Where the controller is of a local type, we have used the output air as a level signal to a board indicator. A dual pilot level transmitter or equivalent is advisable if a narrow proportional band is required in the level controller. This will provide the desired control and a satisfactory level indication.

In all pressure control applications, we have found the hook-up shown in the schematic arrangement satisfactory.

To facilitate controller adjustment and maintenance, we have provided quick coupling connections in the transmitted and controlled air lines for a portable test recorder. These have been located centrally behind the board to avoid interference with the operator. They have been of great value in establishing controller settings and trouble shooting the system. The recorder itself has a two-speed chart drive to show trends in the shortest possible time or during a twenty-four hour period.

A TRAINING AID

Graphic panels have been useful training aids to our organization in a variety of ways. During the early stages in the design of our console type graphic panel, we constructed a quarter scale full color drawing to serve as a model in design meetings. When it had fulfilled its purpose, the Unit Superintendent asked for it. He mounted it on the wall of his office where he used it for quick reference and as a convenient diagram in discussions of operating practice. Later it was moved to the training center where it served technical, supervisory, and operating personnel in an organized indoctrination program. As one of the foremen put it, the drawing was so forceful a man couldn't help but visualize the real thing.

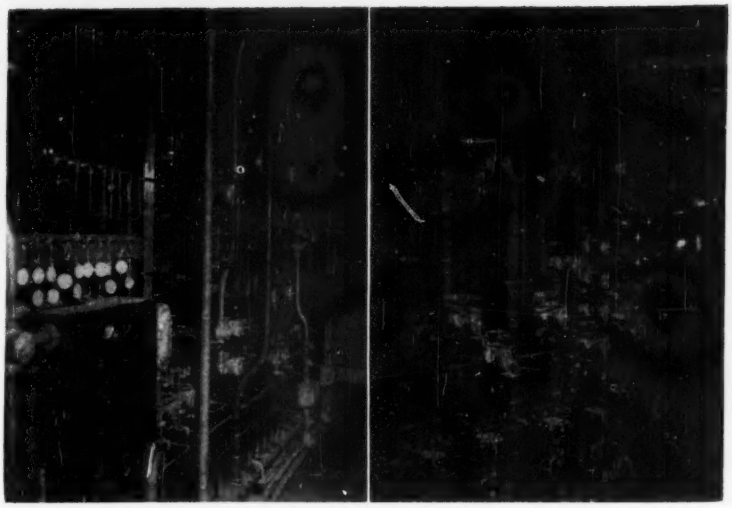


Fig. 3. (Left) Rear View of Flat Type Graphic Panel Showing Test Connections (at left hand side with identifying tags). Fig. 4. (Right) Rear View of Console Type Showing Test Connections (upper left hand corner) and Board Mounted Controllers.

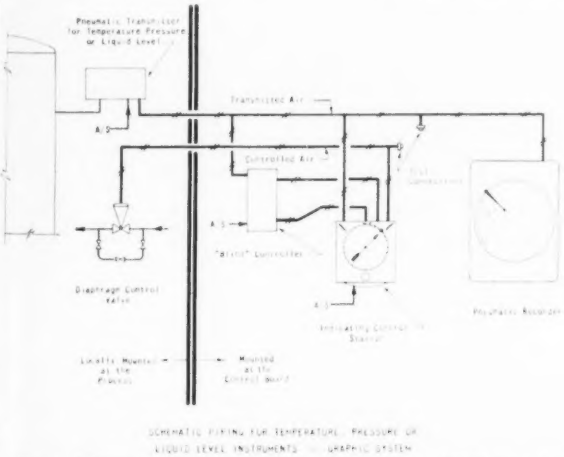
As we had expected, the panel served its purpose admirably during start-up operations. Explanations were clearer, difficult situations easier to handle, and operating technique developed more quickly. The newer men found themselves able to associate instrument functions, operating practice, and equipment more clearly. The veterans too, found the pictorial diagram of great value in sizing up situations.

Our Vacuum Unit graphic panel (which was shown in Fig. 1) is located in the same room with conventional instrumentation for a Propane Deasphalting Unit. Although the panels take up approximately the same space, the Vacuum Unit is much larger and has many more instruments. Both units are operated together by the same crew of men. After three months of experience they had suggestions for improving the method of identifying operating variables, grouping records and more advantageously, and actuating alarms which we incorporated in a later unit. However, their preference for the graphic over the conventional arrangement was almost unanimous. Most of them felt that it had helped them to become familiar with the unit more easily and quickly. As for future panels, there was no question in their minds that they should be designed along graphic lines.

SAVING SPACE AND REDUCING COST

Economies in control room space are important for two basic reasons: first, a smaller board groups the instrumentation within an operator's field of vision so that he can concentrate his attention. This increases his ability to watch the entire process and make the required adjustments. Second, a decrease in panel dimensions reduces control room size and lowers the instrumentation cost.

The pictorial diagram is most useful in co-ordinating thoughts and actions when a unit is in an "upset" condition. This is true in any type of operation but especially in a continuous process. Here the problem of handling the high through-puts with small surge capacities between stages can result in the spread of a difficult situation from



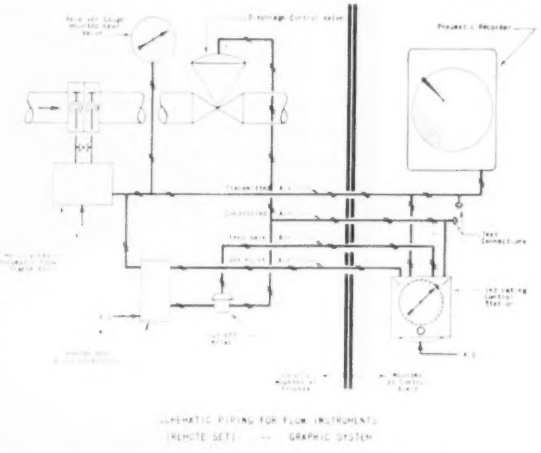


Fig. 5. Schematic Piping for temperature, Pressure or Liquid level Instruments. Fig. 6. Schematic Piping for Flow Instruments. (Remote Set)

one unit to another. For example, our Lima Refinery Lube Plant is designed to process at least four different types of charge stocks. Ample tankage is provided to handle feed and protection requirements. However, the storage between the Solvent Refining and Dewaxing Units is capable of handling over six hours' operation. Imagine the effect a serious tie-up in the Solvent Refining Plant can have on the dewaxing and treating operations which follow. A shutdown of all three operations is definitely possible. On the other hand, if an operator can recognize trouble symptoms soon enough and act promptly, he can prevent a serious situation. Obviously, the compact graphic arrangement improves an operator's understanding of a situation, speeds up his response, and helps minimize potential "upsets".

Fig. 7. Typical Conventional Control Room. Standard Oil Co. (Ohio) Cleveland, No. 1 Refinery.

The opportunity for saving space and reducing over-all cost will vary with each installation and the practices of the individual user. The number of records considered necessary and the preferred layout will be major factors to consider. In citing our own experience, the comparison is between the graphic, illustrated previously in this paper, and the alternate conventional arrangement. This would have consisted of instruments grouped in rows, two high on a panel, similar to that shown in Fig. 7. The type of control and the variables which required recording were chosen from the basic flow diagram before a specific board design had been selected.

In both cases we reduced the panel boards substantially. One board was shortened from twenty-two to twelve ft. and the other from sixty-six to twenty-eight ft. The savings as a result of decreasing the control room size were $2,500 and $13,000 respectively.

Other factors which served to decrease the over-all cost of "graphics" are: first, purchase of factory assembled and pre-fabricated units. On the console type this saved approximately $2,000 over a conventional board assembled in the field. Furthermore, the installation was neater and faster. Second, by combining records on multipoint recorders and using an indicating type of graphic controller ,the cost of the instruments themselves was reduced. This amounted to about $5,000. Third, through the use of multi-point recorders, the chart requirements for these particular units were decreased substantially. We estimate the saving on both will amount to about $400 a year.

In general we found that when the controller was mounted on the board, graphic instruments could be installed for about the same cost as the conventional type. However, the remote set unit, similar to that shown in Fig. 8, with the controller at the process was more costly, since it required four instead of two sets of tubing runs. The exact amount varied with the distance from the control room. We have not yet had an opportunity to analyze these costs completely, but are satisfied that the effect on the over-all installation will be relatively small. The number of this type will rarely exceed 20 per cent of the total.

DISADVANTAGES

Of the disadvantages which were originally considered, only the lack of flexibility continues to present a serious problem.

One shortcoming of the multi-point recorder has become evident from our operations. We find the normal 36 second printing cycle too slow to give an easily readable record in times of "upsets". This is especially true with rapidly changing variables such as flows and pressures. A faster printing cycle, doubling up on recording points, or preferably a graphic recording station should provide the solution. The other instrument components, especially the null balance controllers, have performed very satisfactorily and the system has been almost wholly trouble-free Most of the problems which arose resulted from method of application and were corrected in the field.

We had originally anticipated some system limitations due to the lack of components. At the time our units were designed, the selection of graphic equipment was limited to that of one manufacturer. However, he was very co-operative in adapting his equipment and developing the instruments which were lacking. Consequently, we did not have to compromise our standards of control. There are several new designs on the market now, and the user will find that the necessary equipment can be furnished by at least three additional manufacturers.

The system does lack flexibility when changes are necessary due to alterations in the process. Conventional instruments can readily be relocated when this occurs. In the graphic design, board re-arrangements are difficult unless previously anticipated. This will continue to present a challenging problem to all designers and users. We have not, as yet, encountered any serious difficulties in this respect. The changes we have had to make were either minor re-arrangements of expected additions for which we provided space. For example, we found it necessary to add a liquid level controller to one of the towers. The required indicator was installed in the diagram without any trouble. In another instance, it became necessary to change the process flow slightly. This was accomplished by altering the diagram and interchanging a flow and temperature controller. Several additional alarms were also added in the field without difficulty.

It should be obvious to any user that careful thought must be given to the layout of the diagram. He should consider all possible process changes and determine for himself whether space should be left for them.

EFFECT ON THE INSTRUMENT MAN

Until this point we have stressed the effect of "graphics" on operating personnel. True, they are the primary users and the results they obtain reflect directly upon the performance of the process. On the other hand, accurate, consistent and reliable operation also depends to a large degree on the skill of the instrument man in maintaining the equipment. Naturally, his experiences are very important to the success of the system. Consequently, there has been much speculation as to whether "graphics" improve his understanding of a process or materially effect his maintenance task.

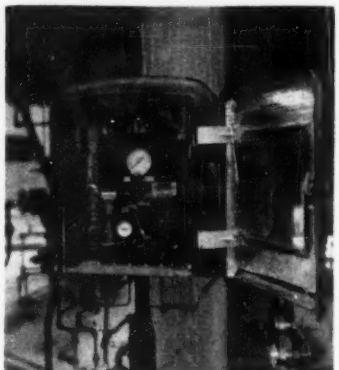


Fig. 8. Typical Installation of Remote-Set Flow Controller. Unit shown is cascade controlled from temperature instrument at panel board.

It is still too soon to draw very many conclusions from the experiences we have had, but some definite trends can be observed.

First, instrument men are almost unanimous in agreeing that the graphic system helps them to understand and become familiar with a unit faster. The relationship of instrument function to the process is more obvious. For example in one particular case an operator reported having trouble in maintaining stable control of a furnace outlet temperature. The instrument man assigned to find the difficulty analyzed the situation quickly from the instruments in the pictorial diagram. He found the charge flow rate fairly steady, the gas flow rate and pressure fluctuating within normal limits, but the temperature tending to climb. Ade-

quate control was only possible by manual regulation of the valve. He quickly established that the temperature instrument was re-setting the gas flow controller. He then checked "proportional bands" and "reset" times of both instruments and located the difficulty. The low limit on the index setting mechanism of the gas flow controller was set too high and, consequently, the valve was not being allowed to close according to the dictates of the temperature instrument. The entire situation was analyzed and corrected in less than thirty minutes. Of course, all problems are not handled so quickly, but the illustration is typical of how the instrument man's job has been affected.

Second, the smaller size of both instruments and control board has not complicated maintenance. In fact, instrument men generally agree that the system has promoted a desirable trend. Instruments built on a unit construction basis, speed up replacement of parts and transfer the repair work from the field to the shop. Thus, if a null balance control unit appears faulty, it is replaced with an identical one and taken to the shop where it can be fully tested and repaired under ideal conditions.

Of course, we have run into situations which have been puzzling and difficult to handle. Many of these have been brought on by the newness of the system. The technique of analyzing trends is somewhat more difficult than for conventional units since the controller and recorder are at separate locations. In anticipation of just such problems, snap coupling test connections have been provided in the transmitted and controlled air lines. These have been centrally located behind the board to permit the instrument man to work without interfering with the function of the operator.

CONCLUSION

It is becoming increasingly clear that the trend in instrumentation is in keeping with the changing function of operators. Industry's investment in modern units often involves the expenditure of hundreds of thousands or even millions of dollars per shift operator. The machines do the work but require the guidance and intelligence of a human brain. Because of the complexity of our newest units, the emphasis has been placed on instrumentation which promotes quick, stable, and accurate operator response. The graphic system, by providing him with a co-ordinated process picture and finger-tip control, furnishes a better tool and helps to improve the quality of control.

We realize that this development is far from being the ultimate. New equipment is now being fabricated and designs perfected which promise even better control in the near future. Progressive improvement will come only through active participation by both designers and users. To this end we shall endeavor to promote the advancement of instrumentation for better control.

The Effect of Transmission Distance on the Stability of Flow-Control Processes

By DAVID B. KIRK *

The control of flow is a problem which frequently confronts the designer of the refinery or chemical-process plant. A great deal has been written about the subject of automatic control in general—and about flow control in particular—and still we don't know all the answers. The universal adoption of the central control-panel, with its long pneumatic transmission lines, raises the question of the way controllability is affected by the length of these lines. An attempt is made here to answer this question in a practical, though elementary, manner.

A basic flow-control system, suitable for the experimental work, is shown in Fig. 1. A centrifugal pump delivers the liquid from a sump, through a substantial length of pipe, to an orifice plate and a flow-control valve. A transmitter, connected across the orifice plate, measures the differential and develops a proportional air pressure. This pressure is recorded on a high-speed chart and is transmitted over a distance to a controller. The controller output is transmitted over the same distance to a diaphragm valve which controls the liquid flow. The set point of the controller is determined by pneumatic loading from a remote-setting station. The pneumatic transmission lines—between the differential pressure transmitter and the controller, and between the controller and the diaphragm valve—are indicated in the diagram.

The system illustrated is a closed-loop control system. The theory of servomechanisms deals extensively with the effects of various time lags on the stability and controllability of closed-loop control systems. Time lags which arise from a variety of conditions, have been classified into several types.

Fig. 2 illustrates a common type of lag, generally referred to as "capacity lag." In this system, the inertia of the liquid in the long line prevents the flow from changing instantaneously when the hand valve is opened. The amount of this lag in most flow circuits is small (having a time-constant of less than a second).

Another type of lag is called "transfer lag." Fig. 3 illustrates a circuit having transfer lag between the orifice plate and the differential-pressure element. Transfer lag may be regarded as two capacity lags in series. It involves the time for transferring a process condition from one process element to the other—each of them having a capacity for storing energy. The time-constant of this lag depends on

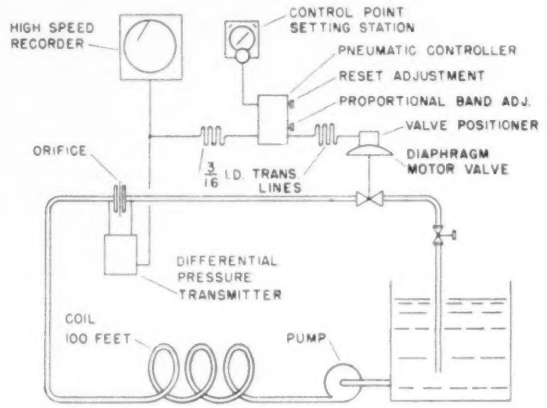


Fig. 1. Closed loop flow control system.

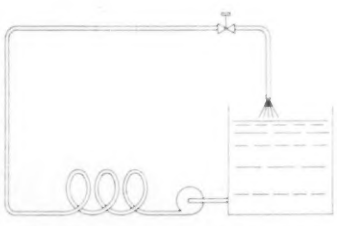


Fig. 2. Circuit with capacity lag.

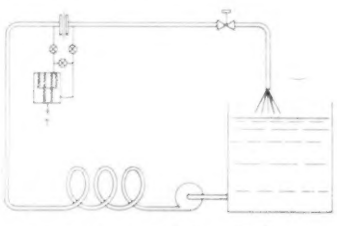


Fig. 3. Circuit with transfer lag.

* Chief Engineer, Moore Products Co., Philadelphia, Pa.

Note:—Presented at the Fifth Annual Conference of the Instrument Society of America, Sept. 18-22, 1950, Buffalo, N. Y.

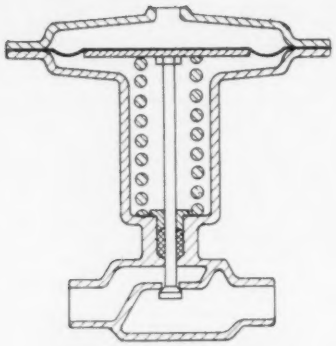


Fig. 4. Diaphragm valve (illustrating dead-time lag).

the storage capacity of each of the elements and on the resistance between these elements. In Fig. 3, the transfer lag varies considerably with the type of measuring instrument. In an undamped differential-pressure transmitter, the time-constant may be much less than one second—whereas, with a heavily damped mercury element, the time-constant may easily reach a value of several minutes.

In the lags described so far, there is no actual time delay, in one sense. A change in the applied condition will change the output condition immediately, although at first the output change may be slight. Another type of lag, however, which may be called "dead-time lag," introduces an actual delay. After the application of the input, there is absolutely no change in the output condition, until a specific time has elapsed. For example, in Fig. 4, a diaphragm-control valve is illustrated. Because there is packing friction, it is obvious that the diaphragm pressure must change a finite increment, before any stem motion results.

All lags in the closed loop, regardless of their source, effect the controllability and stability of the system. A rigorous mathematical analysis of these effects is beyond the scope of this paper—instead, a simplified, practical approach will be used.

Some very useful information can be obtained from studying the transmission characteristics of the closed-loop system. Fig. 5 shows the same system as that shown in Fig. 1, except that the transmission line has been broken between the differential-pressure transmitter and the pneumatic controller. If a pressure which varies sinusoidally with time is applied at terminal A, the train of events set up results in the production of a similar

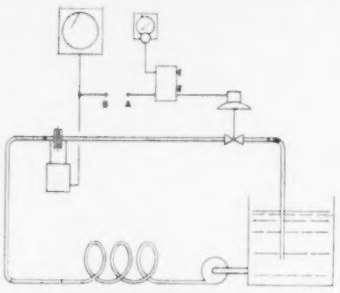


Fig. 5. Flow-control system, set up for applying sinusoidal input.

pressure at B. The relationship between the pressure developed at B and that applied at A is a function of the transmission characteristic and of the applied frequency.

Fig. 6 shows the steady-state relationship between the input and the output pressures for a specific system at one frequency. Notice that both the amplitude and the phase relationship of the input signal are changed during transmission through the loop. The frequency, however, is not changed. The ratio between the amplitude of the transmitted and the applied pressures is the gain of the system. In Fig. 6, the gain is less than unity, because the output is less than the input.

The phase of the two pressures is approximately opposite. This relationship which is fundamental in any control circuit, results from the requirement that the controller must act to reduce the flow when it is too high. In addition to this basic phase displacement of 180°, there is an additional displacement equal to the angle C. Both the gain and the phase displacement depend on the frequency of the applied pressure and on the system constants, including the various lags.

Some of the factors affecting gain are the proportional band of the controller, the characteristics of the control valve, the pressure drop through the valve, the frictional losses in the hydraulic line, and the range of the differential-pressure transmitter. It is obvious, for example, that a narrow throttling range, a steep valve characteristic, or a high pressure drop across the valve will give greater amplitude to the output pressure—thereby increasing the gain of the system. These are all constant factors, substantially independent of the frequency.

One of the transmission characteristics of the control circuit is defined by the relationship between gain and applied frequency, as shown in Fig. 7. Curve A is plotted for a controller with a relatively narrow proportional band and no reset action. Curve B shows the effect of widening the proportional band, and Curve C shows the effect of also introducing reset action. At high frequencies, the gain decreases, so that for practically every circuit there is a frequency high enough to reduce the gain to any desired amount. This relationship between gain and applied frequency results from the presence of lags in the circuit. If all the time lags could be reduced to zero, the gain of the system would be the same for all frequencies. On the other hand, if additional lags are introduced into the circuit, the characteristic will fall more rapidly as the frequency rises. This effect is illustrated by Curve D, which results from the same circuit characteristics as those producing Curve A—except that the transmission lines have been made longer, introducing more lag.

A second useful transmission characteristic is defined by the relationship between the phase displacement of the output pressure and the frequency of the applied pressure. This characteristic is shown in Fig. 8. Because of the inherent reversing characteristic of proportional control systems, the total phase displacement is 180° more than the values shown in the curves. Curve A, which is typical for the flow-control system of Fig. 5, shows that the phase displacement is zero for every low frequency of applied pressure. As the frequency of the applied pressure increases, the output pressure lags more and more behind the applied pressure. The maximum phase displacement is determined by the number of significant capacity elements in the circuit. For each capacity element, the phase displacement will have a limiting value of 90°. Thus, in a two-capacity system, the maximum phase displacement is 180°.

Curve A is typical of a system having two small capacities and Curve B of a three-capacity system, while Curve C is representative of a system having two large capacities. Reset action is equivalent to adding another capacity to the system, since this action introduces a lag which, under some conditions, approaches 90°. Derivative action has the opposite effect on the characteristic, since it is roughly equivalent to reducing the number of system capacities by one.

Examination of the gain and of the phase displacement characteristics will generally determine whether the system will be stable. With the circuit of

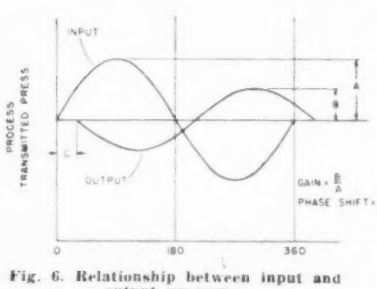


Fig. 6. Relationship between input and output pressures.

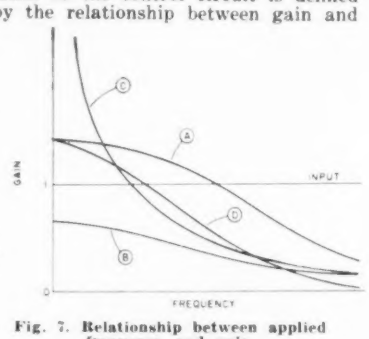


Fig. 7. Relationship between applied frequency and gain.

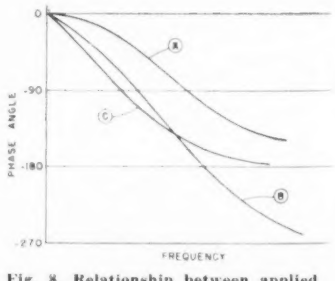


Fig. 8. Relationship between applied frequency and phase displacement.

Fig. 5 closed at A and B, a continuous oscillation can exist only if the phase and the amplitude at A and B are identical. This condition will exist if the gain of the system is unity at the frequency corresponding to 360° total phase shift. If the gain is less than unity, the oscillation will die out. If the gain is greater than unity, the oscillation will increase in amplitude until a limiting condition is reached.

If a comparison of these two frequency characteristics indicates that oscillation will exist, a means for stabilizing the circuit is necessary. The usual approach is to reduce the over-all gain of the system. One of the simplest ways to reduce this gain is to increase the proportional band. The fact that this method has the disadvantage of decreasing the accuracy of control raises a question—whether some other method might be employed to improve stability, without sacrificing accuracy.

Let us investigate the effect of decreasing the lag of the circuit, or of eliminating a capacity element from the circuit. Inspection of the phase characteristic shows that the total phase shift of 360°, which accompanies oscillation, will occur at a higher frequency. If the gain at the higher frequency is less than one, the circuit will not oscillate when the lag is reduced. Although the gain diminishes when the frequency rises, as shown by Fig. 7, the gain characteristic drops less rapidly when the circuit lags are smaller. These two trends are in opposition, so that the net effect on the gain is not necessarily in the direction for stabilizing the circuit.

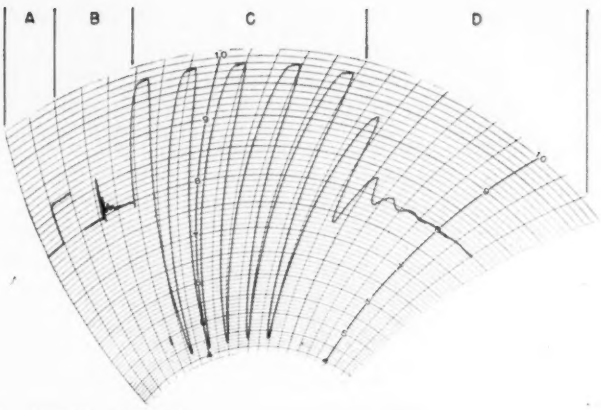
An experimental investigation of transmission-lag effects has been made, using the flow-control system of Fig. 1. This system was set up with time-constants similar to those encountered in modern refineries. The hydraulic lines were one half in. pipe, 115 ft. long, with 10 elbows. The greater portion of the length consisted of a thirteen-turn coil, 2.5 ft. in diameter. The time-constant (i.e. time required to complete 63 per cent of a suddenly applied change) for the hydraulic system was approximately 0.005 minutes, when the diaphragm valve was positioned for a normal flow of 2 gal./min. An undamped bellows type of differential-pressure transmitter was used. Connections to the orifice plate were one quarter in. pipe lines, 6 in. long. This type of transmitter develops an air pressure which is proportional to the differential. The time-constant for the lag introduced by the measuring means was 0.003 minutes. A recorder was closely coupled to the output of the transmitter, so that the lag in the recorder transmission line was negligible. Four different lengths of transmission line were used between the transmitter and the controller and, likewise, between the controller and the diaphragm valve. These lines, of 3/16 in. ID tubing, had lengths of 5, 50, 200, and 600 ft. With each of these lengths, the time-constant of the transmitter and of the controller was as follows:

Tubing Length	Time-Constant
5 ft.	0.003 minutes
50 "	0.005 "
200 "	0.015 "
600 "	0.075 "

The diaphragm valve was equipped with a positioner and was capable of taking the full stroke in 0.06 minutes. Its time-constant for small changes, in the order of 10 per cent of full stroke, was 0.007 minutes.

If the transmission lines are 600 ft. long, the lag in the lines becomes the dominant factor. Then the system behaves as if it had two capacities, and oscillation will occur when the proportional band is too narrow. If the transmission lines are reduced to 5 ft. in length, the lags are reduced—and a much more favorable relationship exists between the gain characteristic and the phase-shift characteristic.

The effect of changing the transmission-line lengths is shown in Fig. 9. Curve A shows the effect of a load upset, when the system is on manual control. Curve B shows the effect of the same upset, with the system on automatic control. For this curve, the proportional band and the reset rate were set at their optimum values for transmission lines five ft. long. The same upset and controller settings were used to produce Curve C, but the transmission-line lengths were 600 ft. The significant fact is that, with short lines in the circuit, all oscillations were damped out in 0.3 minutes, whereas, with long lines, the oscillations were not only sustained but also grew in



A MANUAL CONTROL
B 60% T. R., 0.1 MIN. RESET, 5 FT. TRANSMISSION LINES
C 60% T. R., 0.1 MIN. RESET, 600 FT. TRANSMISSION LINES
D 150% T. R., 0.1 MIN. RESET, 600 FT. TRANSMISSION LINES

Fig. 9. Effect of transmission distance on stability.

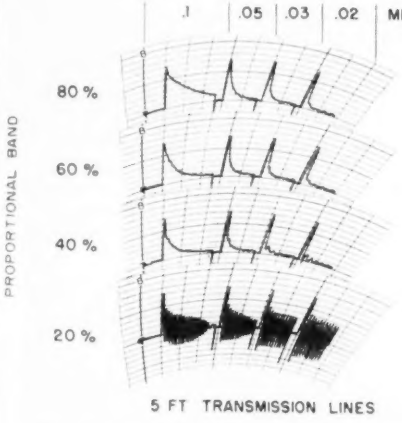


Fig. 10. Effect of proportional band and reset time on recovery.

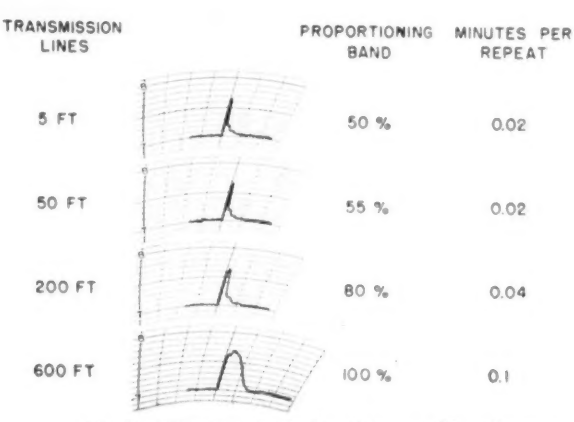


Fig. 11. Effect of transmission distance, with optimum controller settings.

amplitude. Furthermore, when the proportional band was increased from 60 to 150 per cent, the oscillation decreased slowly—even after one minute, the amplitude was still 4 per cent of the normal flow.

In addition to the improvement in stability, other important advantages result from the use of short transmission lines. One of these advantages is the reduction in time required for the process to recover after an upset. If a stable control system is less than critically damped, it will produce oscillations of diminishing amplitude, after a momentary upset. Two control systems, given the same upset and having equal degrees of stability, will produce an equal number of oscillations. If one of the circuits has less lag than the other, the time required for its oscillation to minutes/repeat, the recovery time and the total area under the curve were both at their minimum values.

A similar series of records was obtained for the other lengths of transmission lines. The optimum record from each series is shown in Fig. 11. The proportional band and the reset rate for each of these records are listed, the records show clearly that the system with the short lines has the shortest recovery time. The narrower proportional band and shorter reset time furnish evidence of the greater stability with short lines in the system.

The present practice in the design of refineries and chemical-process plants is to place the flow recorders and setting stations in a central control room, which may be situated several hundred ft. from the flow line. This practice leads to the use of long transmission lines in the control loop, if the controller is installed on a central panel. The benefits from the use of short transmission lines can best be obtained by placing the controller near the point of measurement, and using a remote means of setting the control point from the control room. Fig. 12 illustrates a typical remote-set flow-control system. The controller is located at the point of measurement, thereby eliminating the transmission lines to and from the control room. The minimum lengths of transmission line in the control loop is determined by the distance between the orifice plate and the control valve. Notice that two transmission lines are subject to the measured-variable pressure and to the controller-output pressure, respectively. These lines are dead-ended at the control room—therefore, the control action does not depend in any way on the time required for the transmission of pressure through these lines. The pilots in modern controllers and transmitters have ample capacity for handling the slight load imposed. All other lines merely carry static pressures and are not part of the control loop. An auxiliary switching relay is required to isolate the diaphragm valve from the controller output, when the system is on manual control. A separate feedback connection between the diaphragm valve and the reset unit in the controller keeps the controller in step with the process at all times.

There are many control problems where the recovery time is unimportant, or where the other process lags are so long as to make the transmission lags of minor importance. For these situations, the simpler system of Fig. 13 is recommended. The controller is located in the control room—therefore, the control loop contains the transmission lines for the measured-variable pressure and for the controller-output pressure. All components of both systems can be interchangeable, in order to facilitate conversion from one system to the other—as process conditions require.

There are many factors affecting the controllability and stability of flow-control processes. Valve characteristics, valve-pressure, line-pressure drop, presence of surge chambers, and physical characteristics of the fluid — all these have their individual effects. A complete analysis of all factors requires a much more comprehensive method than is presented here; furthermore, the instrument engineer often cannot control these factors to secure optimum stability. The principles advanced, however, can always be applied, although the improvement in stability obtained will vary somewhat—depending on the other characteristics of the flow-control system.

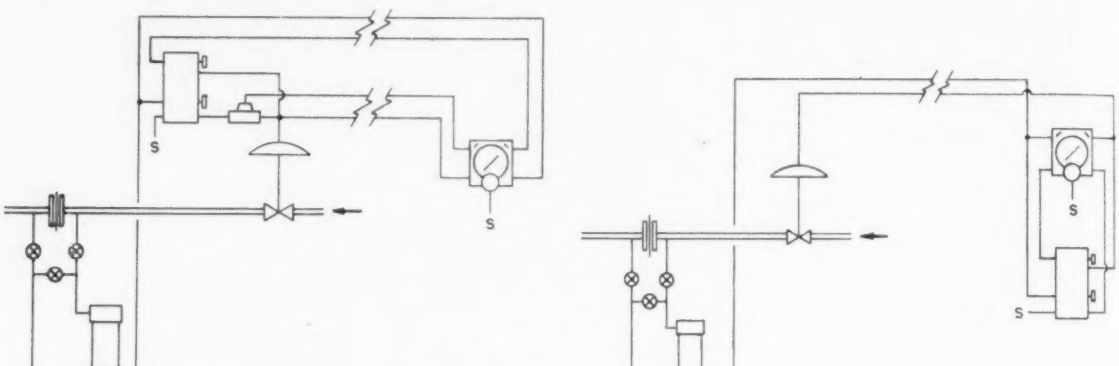


Fig. 12. Remote setting station with field-mounted controller. Fig. 13. Remote setting station with controller in control room.

die out will be less, because of the higher frequency at which the oscillation occurs.

In the experimental systems, shorter recovery time resulted—both from the fact that stability was obtained with a narrower proportional band and from the fact that the oscillation frequently was higher when short transmission lines were used. Figs. 10 and 11 show this improvement. The chart records in Fig. 10 were obtained from the flow-control system having transmission lines five ft. long. The system constants were the same as those used for obtaining Fig. 9, except that the control valve operated over a flatter portion of its characteristic. The initial upset for each record was produced by opening a cock in the flow line. Both the proportional band and the reset rate were set at various values, and a record was obtained for each of the possible combinations. These records indicate that, with a proportional band of 50 per cent and a reset rate of 0.02

JOURNAL of the Southern California Meter Association

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Maintenance *of* Mercury-type Orifice Meters

By MELROY WELCH, Sup't Gas Dep't, Sun-ray Oil Corp., Los Angeles, Calif.

A DEFINITE program of Meter Maintenance is necessary to any company making use of orifice meter records—both to insure the accuracy of those records and to protect the capital investment in the instruments themselves.

The stringency of the program will hinge upon the value placed upon that accuracy of record. The usual *criterion* will be the economics of the measurement. However, the element of public confidence in the company's practice may also enter as a factor for maintaining a high standard of accuracy and the good well-kept appearance of the Meter. Since the aforementioned values will vary greatly between the various measurement set-ups, we can only generalize on the establishment of policy with regard to frequency and care in the servicing of Meters, and leave the formulation of policy up to the department doing the work.

Some of the factors to be considered in establishing a measurement program are:

1. The value of the product passing through the Meter.
2. The severity of the service as to heading conditions, purity of material being measured, etc.
3. The severity of the external conditions such as weather, humidity, fumes, spray, etc.
4. The value one places upon the Public Relations effect of good appearance and accurate measurement.

Each company will undoubtedly have Meters falling under various degrees of importance in the light of the aforementioned factors and will develop a program providing frequent testing and calibration of certain key meters and perhaps only periodic checking of others, with others perhaps so relatively unimportant as to demand service only when obvious error exists, as evidenced by other check meters or the like. The present shortage of manpower is an important factor in keeping these classifications quite distinct.

A good system of Meter Records is an essential to planned Maintenance. A number of such systems are in use and are subject to personal preference.

Notes should always be made upon the chart at the time of making any repairs, adjustments or changes and should be signed by the party who makes them.

Some keep *Meter Notes* in conjunction with the coefficient records, others have separate records for each Meter on an individual card. The author favors a card for each Meter bearing such information as: gage serial number, differential range, pressure range, case type, location, type of spring, type of repairs and adjustments, accompanied by the initial of the party making them and the date on which they were made.

The foregoing program will be designed to serve as over-all protection to the Metering System. However the possibility exists that a mishap might befall a Meter shortly following the routine servicing of it and the attendant error might exist until the next scheduled service period unless some method of detection be used. There are two common methods of detecting errors in measurement.

1. One is through the cross check of recorded volumes by comparing Master Meter Readings, etc.

2. The other—usually the quicker and most practical method—is that of careful chart censoring. That is looking over the charts carefully as they come in from the Meters.

A skilled person can quite successfully diagnose most Meter trouble by comparing the normal record with the record following a mishap to the Meter.

We shall list some of the more common examples.

1. Differential marks below zero continuously.	1. Usually denotes low mercury level.
2. Differential pen marks above chart range.	2. Larger plate indicated or the Meter is filled with condensate.
3. No change is shown in differential when the static shows definite change.	3. Meter is binding due to friction or emulsified mercury.
4. Differential returns to a lower average, following a period exceeding the Meter range.	4. Mercury lost, needs replacement.
5. Climbing or falling non-pulsating differential record, following a normal record.	5. Tapelines fouled, generally due to freezing or hydrates forming.
6. Either static or differential pens apparently gain or lose time in moving over chart range.	6. Pens out of adjustment as to length.

There are a few common variations in chart records which are sometimes misinterpreted, such as:

1. A depression of differential reading to the extent of about two tenths of an inch water differential per 500 lbs. pressure.

2. A variation of meter zero to the extent of about one-third of one percent of maximum range of differential per 50 degree temperature variation.

3. A variation of about one percent in pressure spring reading per 50 degree temperature change.

In considering the work to be done in adjusting and repairing meters, consideration should be given the tools to be used in doing such work. Individual preference will govern their selection to some degree. However, the following list is submitted as a minimum kit for general service. A number of additional shop tools will be needed for 100 percent shop overhaul purposes.

A suggested minimum tool list for field service:

1. (1) Suitable small tool box. (The author prefers an open rack type tool box with tools individually procurable.)
2. (1) 50-in. Manometer with connecting hoses and aspirator bulb.
3. (1) Test Gage of suitable range.
4. (1) 12-in. Crescent wrench.
5. (1) 6-in. Crescent wrench.
6. (1) 4-in. Crescent wrench.
7. (1) 10-in. rigid pipe wrench.
8. (1) 6-in. rigid pipe wrench.
9. (1) 8-in. Flex handle (Plomb #5466)
10. (1) 7/16-in. 12-point socket.
11. (1) 9/16-in. 12-point socket.
12. (1) 5/8-in. 12-point socket.
13. (1) 6-in. Side cutting lineman pliers.
14. (1) 5-in. Long nose instrument pliers.
15. (1) 5-in. Instrument tweezers.

December Meeting: Thursday the 21st, Rio Hondo Country Club, Downey, Calif. Dinner at 6:30, meeting at 8:00 p.m.

Features: (1) Past President's Night; (2) Steam Traps—Personal experiences with Admiral Byrd in 1941 and personal experiences of the South African Tour, by L. C. Musselman.

[1] Presented at the regular meeting of the Southern California Meter Association, August 17, 1950.

16. (1) 1½-in. Over-all by 1/16-in. bit screwdriver.
17. (1) 4-in. Over-all by ⅛-in. bit screwdriver.
18. (1) 7-in. Over-all by 3/16-in. bit screwdriver (Plomb #9632)
19. (1) 12-in Over-all by ⅜-in. bit screwdriver.
20. (1) 3-in. Starret pin vise with 3-in. piece of #60 ga. spring wire.
21. (1) Stainless steel teaspoon (for mercury)
22. (1) Clock Key
23. (1) Dill-Presto Oiler,
24. (1) #2 Paper clip for holding chart.
25. (1) 8-in. Flat file.
26. (1) ½-in. Paint brush.
27. (2) Small calibration adjusting wrenches.
28. (1) 6-in. or 8-in. Combination level (Plumb and Horizontal bulbs)
29. (1) ¼-in. Standard pipe tap.
30. (1) Inside outside caliper rule (Starrett #425)
31. (1) 6-ft. Steel rule.
32. (1) Lubricator for greasing differential stuffing boxes.
33. (1) Tube distributor grease (Ford)
34. (1) Tube Permatex #2 for thread dope.
35. (1) Pint Mason jar for cleaning solvent.
36. (1) Roll friction tape.
37. (1) Fine Arkansas slip stone (for shaping pens).
38. (1) Pair ink bottles.
39. (1) Putty knife.
40. (1) Ear syringe for washing pens.
41. (1) Battery syringe.
42. (1) Pint jar with miscellaneous meter parts and the following:
    1—length of watchmaker BSA #60 spring wire.
    1—length of watchmaker BSA #20 spring wire.
    1—ink dropper.
    1—tube Lubriseal.
    1—short length graphited string packing.
    1—set pen points.
    1—each of miscellaneous meter parts.

In this discussion of Meter Maintenance, we shall consider Maintenance Service as applying to the following elements of a Meter:

1. **The Differential recording element.**
2. **The Static recording element.**
3. **The Time recording element.**
4. **The Meter Manifold and tap lines.**
5. **The external parts of the Meter Case, etc.**

A statement of the ideal state of adjustment of a meter might embrace the following:

1. The differential pen should follow the arc of the chart bearing lightly against the paper and should move freely up and down the scale to settle at zero after going slightly below, then above, and finally rest on the zero line, and upon checking should follow the water column exactly, throughout the range of the meter.

2. The static pen should move freely touching lightly and record 15 minutes earlier than the differential pen, and check with a test gage throughout its range.

3. The clock should run smoothly and record the time correctly.

4. The meter manifold should be free from leaks, free from rust and condensate; valves should close securely and open easily and be so arranged as to permit the easy testing of the meter.

5. The meter case, house, etc., should be clean and well painted so as to portray an air of being well kept.

A series of suggested procedure sheets will follow indicating how to make the essential adjustments to an orifice meter.

Operation Sheet on the Differential Recording Element

Problem—To Calibrate the Differential Element

Equipment:

Tools as per tool list.
1 50-in. Water manometer.
1 Aspirator bulb and hose.
1 Meter chart of proper differential range, or conversion chart for square root charts.

Procedure:

1. By-pass and shut-in Meter and open to atmospheric pressure.
2. Attach 50-in. manometer and if no pressure is available attach the aspirator bulb.
3. Place the inches of water chart on the meter.
4. Check the Mercury level and adjust with ¼-in. sub-zero adding or removing Mercury if necessary.
5. Check chart at 0 then run out to maximum range of Meter.
6. If pen reads more than the manometer, remove the meter cover and lengthen the linkage, or, if it reads less than the manometer, shorten the linkage. Rerun and adjust until it checks, then check at three or four points going up and coming down and if there is any lag check all points and remove friction by lubricating or polishing the parts.
7. Enter note on chart concerning findings and the work done and sign.
8. Return Meter to operating service.

Operating Sheet—"To Calibrate the Static Element"

Equipment:

Tools as per tool list.
1 suitable range test gage (or dead weight Tester)
1 Meter Chart of proper pressure range or proper conversion table for square root charts.

Procedure:

1. By-pass and shut-in the Meters and open to atmospheric pressure.
2. Check differential pen to arc, then set static pen 15 minutes faster.
3. Oil all bearings and check all points of friction on static element linkage and adjust pen pressure so as to float free when the face is depressed ⅛ in. by pressing in on the face plate and chart with the thumb.
4. Connect test gage and check pen reading at zero and at maximum range.
5. If pen reads less than gage, shorten the linkage. If more, lengthen the linkage. Readjust it to zero and repeat until it checks.
6. Increase the pressure, check at three or four points up and down the scale, if there is any drag, eliminate it. Check particularly at the working range.

Operation Sheet—"To Service the Meter Clock"

Equipment:

Tools as per tool list.
Clock oil.
Cleaning brush and toothbrush.
Cleaning solvent.

Procedure:

1. If clock is very dirty, disassemble and scrub parts in solvent, using a fairly stiff brush, or paint brush.
2. Re-bush worn bearings by drilling out old bearing and replacing with bushing stock, then ream the bearing to fit the shaft.
3. Replace broken or worn parts.
4. Reassemble and center the balance wheel swing by adjusting the length of hair spring.
5. Adjust the verge and hatchet gear to provide an even, strong swing.
6. Oil the bearings and hatchet gear teeth.
7. Adjust to time by regulating the time lever which snubs the hair spring.

Operation Sheet—"To Service the Meter Manifold"

Equipment:

1 Tools as per tool list.
2. Valve stem packing.
3. Auto distributor grease or equivalent.
4 Soap suds and brush.

Procedure:

1. Disconnect header from Meter and blow tap lines to remove foreign matter. If either high or low side seems obstructed, break down fittings and probe out foreign matter.
2. Remove bonnet and stem from valves, screw stem on through the bonnet. Grease threads of stem heavily with distributor grease or equivalent.
3. Repack packing gland with suitable graphite-impregnated packing smeared with grease. Reassemble.
4. If header is very rusty, treat as the rest of the meter, by sandblasting and repainting.
5. Reassemble header and check for leaks by means of soap suds.

Operation Sheet—"To Completely Refinish Meters"

Equipment:

1. Tools as per tool list.
2. Suitable paint and brushes or air gun.
3. Sand blast service. (Would suggest the local Monument works.)

Procedure:

1. Completely disassemble Meter.
2. Have Meter and parts carefully sand-blasted.
3. Paint all castings and case with two coats of zinc chromate primer. Paint inside chambers and floats with a dull finish oil primer, such as "Fuller Black Metal Primer."
4. Paint with one coat of finish coat, enamel or the like.
5. Reassemble Meter replacing worn parts.
6. Calibrate Meter.
7. Apply over-all finish coat.

Maintenance Notes

Much maintenance work may be eliminated by proper choice of materials in original installations, such as:

1. Large opening stop clocks at Orifice connections.
2. Large opening tap lines with ample slope for drainage.
3. Use of plastic or copper tubing.

4. Use of stainless steel valves.

5. Arrange for top openings for taps on the Meter run, eliminate moisture entrance to tap lines and to insure proper drainage.

Random Shop Notes

When repacking valves, pull bonnet and grease the rising threads.

A good pen cleaner may be made from pieces of static tubing and No. 60 wire.

Make ink from glycerine and color dye to eliminate acid eating of pen by the average commercial ink.

Use Colloidal Graphite for lubrication of differential bearings.

Poor clocks may be spotted by irregular ticking.

Differential shaft packing, use graphite string package and Lubriseal and cardboard washers.

A useful packing hook may be made from a crochet hook or from heavy spring piano wiring.

Parkerize inside of Meter to minimize corrosion.

To change degree of choke in choke bushings cut them off and vary degree of choke by their length.

To remove old style mercury drain screws, tap sharply with two hammers from opposite sides. If the screw head is broken, file away part of the stock around and tighten hand vise on the stub and remove.

Sand blasting is much more thorough than caustic cleaners for removing paint and rust, but if a strong cleaner is to be used, use only that which is inhibited for Aluminum use.

Taping ink bottles together with friction tape minimizes spilling.

Leave 1/32-in. end play to differential shafts, to insure free operation.

Lapping-in differential bearings insures friction free operation, particularly on high pressures.

To level Meters, do so on the 2-in. vertical riser, rather than on the Meter itself.

Lap the seats of check valves and run in ¼-in. tap to insure proper depth spacing of check valves in the casting.

Check differential shafts for straightness by rolling on a piece of plate glass.

FOSTER FLOW TUBE

Gentile Patents

FIVE FEATURES

for your Consideration:

1 . . . Compactness Note in the picture above the short axial length. Tubes 3" in size and larger are approximately 1 to 1½ diameters long, depending upon the velocity in the main. For high main line velocities (above 10 ft/sec. for liquids) tubes are less than 1 diameter in length.

2 . . . Ease of Installation Due to its compactness and because it requires no straight runs upstream or downstream, except near valves or regulators, the total space required for installation is but a small fraction of that necessary for other primary devices. It can be installed as readily as a fitting and in that section of the line most conducive to steady flow conditions. Moreover, it can be installed in the plant proper, eliminating the need for expensive vaults or housing.

3 . . . Reversibility The Foster Flow Tube is symmetrical transversely; upstream and downstream nozzles and ports are identical. This means that where processing calls for flow reversal, the meter can readily handle the changes.

4 . . . Low Head Loss Where head losses are important Foster Flow Tubes are designed with a main-to-throat ratio that provides negligible unrecovered head losses.

5 . . . Accuracy All Foster Flow Tubes are furnished with calibration curves obtained in laboratory tests simulating installation conditions and can therefore be guaranteed to an accuracy to meet any specification.

Foster Flow Tubes are recommended for a wide range of services metering the flow of liquids and wet or dry gases. They are available in all commercial pipe sizes with flanged or screwed connections. Standard lining is bronze but other materials are available. In writing for further information, give processing and installation details of your metering requirements.

FOSTER ENGINEERING Company

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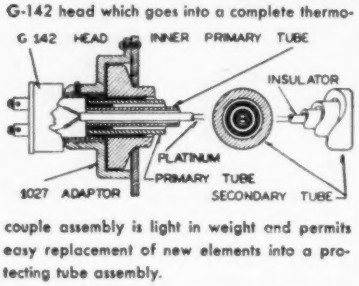
The porcelain insulation and protecting tubes which go into a complete thermocouple assembly are of the finest quality obtainable. They are the best known means of preventing contamination of the elements which result in false e.m.f. values. Also, the Gordon G-142 head which goes into a complete thermocouple assembly is light in weight and permits easy replacement of new elements into a protecting tube assembly.



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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on Page 1203.

Requests for literature FROM ABROAD should be made on company letterhead and mailed DIRECTLY to the manufacturers.

S-684 RADIOACTIVITY DETECTOR. 2-page bulletin illustrates and describes maker's "Super Sniffer" radioactivity detector for uranium prospecting; covers features, advantages, price.—Nuclear Instrument & Chem. Corp., Chicago, Ill.

S-685 DIAPHRAGM CONTROL VALVES. 4-page Bulletin S10 describes and illustrates maker's "Series 1200 and 1400" diaphragm control valves; covers features, construction, available inner valves, dimensions, characteristics, and specifications.—Kieley and Mueller, Inc., 2033 43rd St., North Bergen, N. J.

S-686 LOW WATER CUTOFF. 4-page Bulletin 911 illustrates and describes maker's "Lectrol" automatic low water cutoff for all gas and electric water stills; covers features, advantages, and data for ordering.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

S-687 "MICRO TIPS." 4-page Vol. 1, No. 6 issue of this house organ features articles on various uses of maker's snap-action switches.—Micro Switch, Freeport, Ill.

S-688 RADIO, TV CATALOG. 212-page 1951 catalog, "Everything in Radio, Television, and Industrial Electronics," covers equipment for industrial maintenance, research and production requirements; includes sections on radioactivity counters, public address amplifiers and sound systems, recording equipment, radio sets and TV chassis.—Allied Radio Corp., 833 W. Jackson Blvd., Chicago 7, Ill.

S-689 DRAWING STENCILS. 4-page brochure illustrates and describes maker's "Instrumaster" isometric protractors, isometric 2-angle and ellipse stencil, dimetric 2-angle and ellipse stencil, hatching stencils, and others; includes prices.—John R. Cassell Co., Inc., 110 W. 42nd St., New York 18, N. Y.

S-690 INSTRUMENTATION DATA SHEET. 4-page Instrumentation Data Sheet No. 9.1-3 contains article titled "Continuous Record of Electrical Power Increases Central Station Efficiency—Accurate and Rapid Measurement of Useful Power with Check on Reactive Power Prevents Overloading of Generators."—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Penna.

S-691 FREQUENCY MEASUREMENT. 6-page Bulletin 1090 illustrates and describes C. G. Conn, Ltd. "Stroboconn" stroboscopic-type direct-reading frequency meter; covers features, use, construction, industrial applications, specifications.—Alfred Crossley & Associates, 4501 N. Ravenswood Ave., Chicago 40, Ill.

S-692 "THE C-D CAPACITOR." 16-page Vol. 15, No. 9 issue of this house organ features article titled "Resonant Capacitors in Radio Receiver Circuits"; contains regular feature "The Radio Trading Post—A Free Market-place for Buyers, Sellers, and Swappers."—Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

S-693 "TIC LABORATORY REPORT." 4-page No. 1 issue of this house organ features article titled "Low Frequency Characteristics of the Type 320-A Phase Meter."—Technology Instrument Corp., 1058 Main St., Waltham, Mass.

S-694 "TIC LABORATORY REPORT." 6-page No. 2 issue of this house organ features article titled "Determination of the Q of Coils by Means of a Z-angle Meter and the Series Resonance Method," also illustrates and describes maker's network calculators, and "Type 500-A" wide band decade amplifier.—Technology Instrument Corp., 1058 Main St., Waltham, Mass.

S-695 "THE LABORATORY." 24-page Vol. 20, No. 1 issue of this house organ features articles titled "Science Stabilizes Economy in the Land of Sunshine," "Fisher Takes Over TAI Line of Petroleum Testing Instruments," and articles on "Beckman" automatic titrator, burner wingtop for Pyrex tube bending, and other laboratory devices.—Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Penna.

S-696 "INSTRUMENT NEWS." 8-page Vol. 1, No. 4 issue of this house organ features articles titled "Classification of Infrared Spectra—Punch-Card Committee Progress Report," "Polarized Infrared Spectra Determine Crystal Structures," "Alkali Control in Cement Industries"; also articles on maker's 10-in. apochromatic refractor, the "Model 38" Tiselius electrophoresis apparatus, and "Model 52-C" flame photometer.—The Perkin-Elmer Corp., Glenbrook, Conn.

S-697 TV DATA SHEETS. 8½ x 11 binder-punched TV control and resistor replacement data sheets cover RCA, Du Mont, Stromberg-Carlson, Crosley and Emerson models; contain reference charts indicating model and chassis stock and part numbers, catalog number, price, function and description.—Clarostat Mfg. Co., Inc., Dover, N. H.

S-698 VISCOMETER ADAPTER. 2-page Data Sheet 034 describes and illustrates "UL" adapter for measurement in ultra-low viscosity ranges (0 to 10 centipoises) with "LV" models of maker's viscometer; covers features, specifications, price, and use.—Brookfield Engineering Laboratories, Inc., Stoughton, Mass.

S-699 ELECTRONIC AND ELECTRICAL COMPONENTS. 72-page Catalog No. 300 illustrates and describes maker's terminal lugs, terminal boards, swagers, hardware, insulated terminals and standoffs, coils and chokes; includes drawings and technical data on each unit; encloses revised price list.—Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.

S-700 GEIGER COUNTERS. 4-page folder contains article titled "Counters" by Dr. Serge A. Korff, and reprinted from *Scientific American*, July 1950; covers elements and use of Geiger counters, behavior of electrons, positive ions, ion clouds and impulses, penetrating, non-penetrating and decaying cosmic ray particles, and data on special counting circuit arrangements. Price 10 cents.—Bureau of Public Information, New York University College of Engineering, New York 53, N. Y.

S-701 HYDRAULIC VALVE CATALOG. 52-page Catalog Section 202 illustrates and describes 90 different models of 4-way hydraulic valves; includes drawings, specifications, circuit layouts showing arrangement of all necessary hydraulic equipment; covers 25 models of oil pilot valves for remote control of main 4-way valves, and valves for flow control, shut-off and deceleration, relief, sequence, unloading and counter-balance.—Rivett Lathe & Grinder, Inc., Brighton 35, Boston, Mass.

S-702 CATHODE-RAY TUBES. 12-page booklet covers characteristics for 103 magnetic-type and 91 electrostatic-type c-r. tubes; includes heater current and voltage data, nominal dimensions, persistence and fluorescence of screen, maximum design center ratings, and typical operating conditions. Contains table of phosphor characteristics, basing diagrams, and suggestions for physical handling and high-voltage circuit

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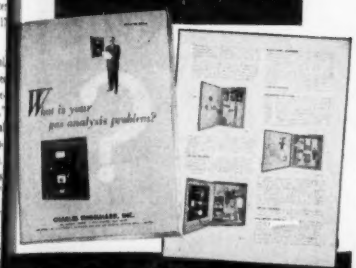

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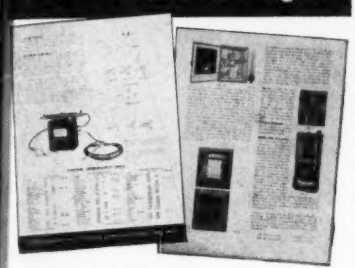

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adjustment practice.—Sylvania Electric Products Inc., Emporium, Penna.

S-703 COMPONENTS FOR PLUG-IN, UNIT CONSTRUCTION. 24-page booklet covers maker's components for plug-in, unit construction (back-connected slide-in lock-in chassis, color-coded back connectors, plug-in unit housings and bases, etc.); covers features, operation, application of each type; encloses 4-page bulletin on maker's indicator lights, fuseholders, connectors, plugs and jacks, etc.—Alden Products Co., 117 No. Main St., Brockton, Mass.

S-704 INSTRUMENT DESIGN, DEVELOPMENT, MANUFACTURE. 4-page Form 41850 illustrates and describes facilities for instrument design, development and manufacture; includes nine specific projects in fields of mechanics, optics and electronics—covering tooling, aeronautical research, time-measurement photography, production dispatching equipment, microwave radar components and high-speed centrifugal power units.—Beckman & Whitley, Inc., 930 San Carlos Ave., San Carlos, Calif.

S-705 "ELECTRONIC PNEUMATIC MECHANICAL INSTRUMENTATION." 40-page Vol. 4, No. 6 issue of this house organ features articles titled "Cit-Con Advances Lube Oil Frontier," "Quality Control and pH Control Synonymous at Newton Falls Paper Company," "Nylon Heat Setting," "Recording Electric Power," "Instrument Operating Principles," "Research in Supersonics at Princeton University," and others.—Industrial Div., Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Penna.

S-706 PORTABLE HARDNESS TESTER. 2-page bulletin describes and illustrates maker's "Impressor" portable hardness tester for aluminum, aluminum alloys, soft metals and plastics; covers use, engineering data, features.—Barber-Colman Co., Rockford, Ill.

S-707 PLUG VALVES. 2-page bulletin illustrates and describes maker's screwed or flanged lever-operated, gear- or air-operated, and air-or-water cylinder-operated plug valves; covers features, sizes, and prices.—The DeZurik Shower Co., Sartell, Minn.

S-708 SHADED-POLE MOTORS. 4-page bulletin illustrates and describes maker's fractional-hp. shaded-pole motors for instrument and other applications; covers specifications, characteristics, and dimensions of unidirectional, synchronous, reversible, and unidirectional and reversible models.—Barber-Colman Co., Rockford, Ill.

S-709 "COOK MAGNILASTIC NEWSLETTER." 4-page Vol. 2, No. 11 issue of this house organ features pictorial titled "Expansion Joints at Work," describing installations of maker's expansion joints; includes chart of symbols for diagramming piping layouts.—MagniLastic Div., Cook Electric Co., Chicago 14, Ill.

S-710 ELECTROMAGNETIC CLUTCHES. 2-page bulletin describes and illustrates maker's electromagnetic clutches for machine tool servos, indexing devices, table feeds, etc.; covers features, specifications, operation.—Barber-Colman Co., Rockford, Ill.

S-711 PHOTOGRAPHIC RECORDING. 2-page bulletin illustrates and describes maker's "Varitron" photographic recording camera for technical, industrial and scientific applications; covers features, construction, applications, and principle of operation.—Photographic Products Inc., 955 N. Mansfield Ave., Hollywood 38, Calif.

S-712 POWER UNITS. 4-page bulletin illustrates maker's power units for industrial combustion applications; covers use on valves, blower-mixer, burners.—Barber-Colman Co., Rockford, Ill.

S-713 MOISTURE CONTENT CONTROLLER. 4-page bulletin describes and illustrates maker's "ADR Drimeter" for continuous moisture content control in fabric and warp; covers features, use and operation.—Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Penna.

S-714 ELECTRONIC POLARIZED RELAY. 2-page bulletin illustrates and describes maker's electronic polarized relay for use in self-balancing a-c. bridge circuits; covers construction, operation, installation, uses, dimensions, electrical characteristics, specifications.—Barber-Colman Co., Rockford, Ill.

S-715 TENSILE TESTER JAWS. 2-page bulletin describes and illustrates maker's tensile

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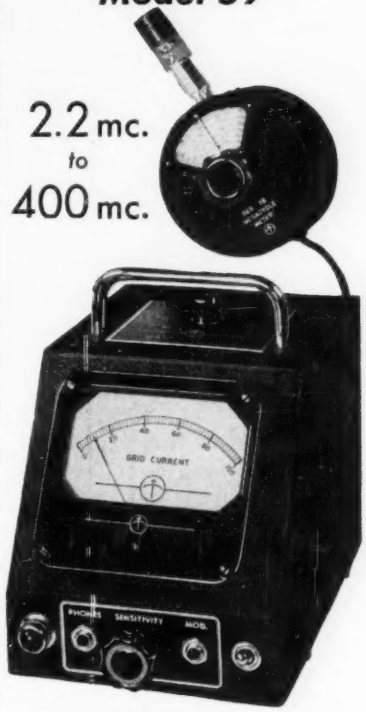
2.2 mc. to 400 mc.



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- As an auxiliary signal generator; modulated or unmodulated.
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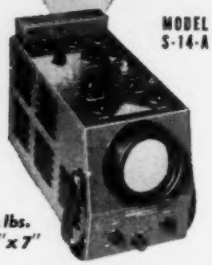

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testing machine jaws with resilient follow-up action; covers features; applications, specifications.—Instron Engineering Corp., 2 Hancock St., Quincy 71, Mass.

S-716 INSULATION RESISTANCE TESTERS. 4-page Bulletin 2A illustrates and describes maker's "Vibrotest" insulation resistance testers; gives full data on 29 models; covers advantages, applications, specifications, and Wheatstone bridge combinations.—Associated Research Inc., 3766 Belmont Ave., Chicago 18, Ill.

S-717 "WHEELCO COMMENTS." 4-page Vol. 10, No. 1 issue of this house organ features articles titled "Close Tolerances Required for Extrusion of Plastic Sheeting," "Canadian Manufacturer Uses Versatile Machine for Moulding Rubber Products," and "New Horizontal Tube Furnace Aids in Crystal Development."—Wheelco Instruments Co., Harrison and Peoria Sts., Chicago 7, Ill.

S-718 BROADCAST EQUIPMENT. 3 catalog sheets illustrate and describe maker's broadcast equipment: Sheet .904 Section B covers features, uses, specifications on "Type WM-30A" phase monitor and accessories; Sheet .916 covers "Type WX-2C" field intensity meter; Sheet .946 covers "Type WA-26A" tone generator, and "E1-11A" transmission measuring set.—Radio Corporation of America, Harrison, N. J.

S-719 TEMPERATURE, PRESSURE INSTRUMENTS. 56-page Catalog No. 101-J describes and illustrates maker's industrial thermometers and accessories, miscellaneous and engraved-stem thermometers, hydrometers, dial-indicating and recording thermometers, recording pressure gages, panel boards, air-operated temperature and pressure controllers, diaphragm motor valves, self-operating temperatures, etc.; gives complete technical data, features, applications, and prices.—H. O. Trerice Co., 1420 W. Lafayette Blvd., Detroit 16, Mich.

S-720 LIQUID-LEVEL CONTROLLERS. 32-page Catalog 1048 describes and illustrates maker's all-electric floatless liquid-level and industrial controllers; covers operation, specifications and features of induction relays, multiple pump controllers, electrodes, magnetic contactors and starters, etc.—B/W Controller Corp., 2200 East Maple Road, Birmingham, Mich.

S-721 TUMBLER-MIXER. 2-page bulletin illustrates and describers maker's "Lanco" laboratory tumbler-mixer for solids or liquids; covers specifications, features; also describes and pictures maker's thermometers, alcohol blow torch, and safety cylinder support.—Arthur S. La Pine & Co., 121 W. Hubbard St., Chicago 10, Ill.

S-722 ELECTRICAL TEST EQUIPMENT. 4-page 1950-51 Catalog describes and illustrates maker's vacuum-tube voltmeters, oscilloscopes, sweep generators, signal generators, tube testers, signal tracers, volt-ohm-milliammeters, battery eliminators, high-voltage probes, r-f. probes, crystals; covers features, specifications, prices.—Electronic Instrument Co., Inc., 276 Newport St., Brooklyn 12, N. Y.

S-723 PHOTOELECTRIC SYSTEMS. 16-page Bulletin 850 illustrates and describes use of maker's "Fotolectric" systems in various applications (counting, sorting, grading, controlling size, thickness, color, etc., detection and regulation).—Warner Electronic Devices, Rankin, Ill.

S-724 RADIOISOTOPES IN MEDICINE. 4-page bulletin describes and illustrates some diagnostic applications, therapy and instruments utilizing radioisotopes.—Nuclear Instrument and Chem. Corp., 223 West Erie St., Chicago 10, Ill.

S-725 "THE OSCILLOGRAPHER." 24-page Vol. 12, No. 2 issue of this house organ features articles titled "Techniques of Photo-recording," "A Single-sweep Triggering Circuit," and items on maker's "Type 314-A" oscillograph-record camera, "Type 5XP" cathode-ray tube, and others.—Instrument Div., Allen B. Du Mont Laboratories, Inc., 1000 Main Ave., Clifton, N. J.

S-726 AIRCRAFT THERMOCOUPLES. 12-page Section 12 illustrates and describes maker's aircraft and engine thermocouples for all pyrometers; covers features, specifications, ordering information.—Thermo Electric Co., Inc., Fair Lawn, N. J.

S-727 THERMOCOUPLE CONNECTORS AND PANELS. 4-page Catalog Section 23 illustrates and describes maker's quick-coupling type thermocouple connectors and panels; covers

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